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DANA.

Instruction Manual

980441

MODEL 600 SIGNAL CONDITIONING MODULE for SERIES 5300 DIGITAL MULTIMETERS

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INSTRUCTION MANUAL

MODEL 600

SIGNAL CONDITIONING MODULE

This manual is to be used in conjunction with the 5330/5370 Digital Multimeter manual.

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Warranty

Within one year of purchase, Dana Laboratories will repair or replace, at our option, your instrument if in any way it is defective in material or workmanship. All parts and labor charges will be paid by Dana Laboratories. Just return the instrument to your nearest authorized Dana Service Center freight prepaid. We will return it to you freight prepaid.

DANA

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SECTION 1

INTRODUCTION

1.1 SCOPE.

1.2 This manual covers Signal Conditioning Module 600 used with Model 5330 or 5370 Digital Multimeters (mainframe assemblies). Descriptions of the digital and readout sections are included in the appropriate Digital Multimeter manual.

1.3 MECHANICAL DESCRIPTION.

1.4 The Signal Conditioning Module comprises the right-hand side of the 5330 Multimeter and the lower half of Model 5370. It includes circuits that convert the input to a ten-volt full-scale (plus 20% overrange) analog voltage for measurement by the digital circuits in the multimeter.

1.5 Model 600 measures d-c voltages on five ranges, from ±.1V to 1000V (plus overrange). Optional accessories enable the measurement of AC, Ohms, or both. Accessory model numbers are listed below:

Model 50 AC Converter
Model 60 Ohms Converter
Model 70 AC/Ohms Converter

Model 50 provides AC measurements on four ranges, from 1V to 1000V rms. Model 60 provides Ohms measurements on five ranges, from 1 Kilohm to 10,000 Kilohms. Model 70 combines the capability of the other two accessories.

Figure 1.1 - Model 5370/600 Digital Multimeter

1.6 ELECTRICAL DESCRIPTION.

1.7 A block diagram of the Signal Conditioning Module is shown in figure 1.2. For DC measurements, the input is applied to a voltage divider that divides the input voltage by 1 or by 100 depending on the full-scale range. The scaled input is applied to the Isolator amplifier which delivers ten volts full-scale to the digitizing circuits in the multimeter mainframe assembly. The gain of the Isolator is 1, 10, or 100 depending on the range.

1.8 For AC measurements, the AC Converter scales the input and rectifies it. The converter output is applied through the voltage divider (set to 1:1) to the Isolator, set to a gain of 1.

1.9 For Ohms measurement, the Ohms Converter monitors the output of the Isolator to provide a constant current to the input terminals. The amount of current is dependent on the range selected. The DMM measures the voltage drop across the unknown resistance connected between the input terminals. The input voltage is applied to the voltage divider (set to divide by one) and then applied to the isolator amplifier, set to a gain of 1, 10, or 100.

1.10 The module is equipped with autorange circuits that switch to the optimum range automatically in AC, DC, and Ohms measurement modes.

1.11 SPECIFICATIONS.

1.12 Specifications are listed in table 1.1.

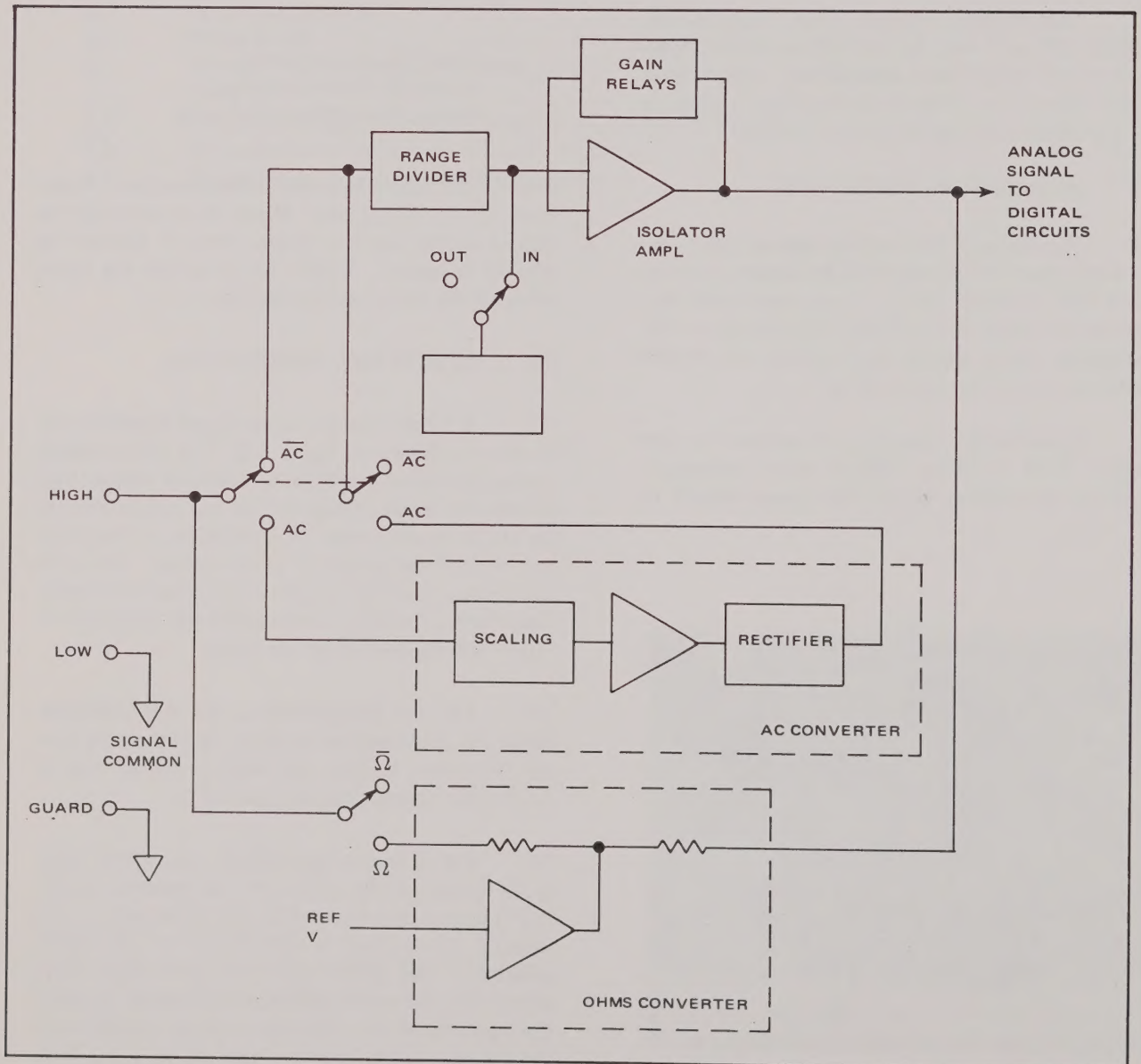


Figure 1.2 - Block Diagram

Table 1.1 - Specifications

DC

Full Range Display:	±.100000, ±1.00000, ±10.0000, ±100.000, ±1000.00
Overrange:	20% on all ranges, ±1000 volts maximum input
Resolution:	1 microvolt
Accuracy*:	
24 hours, 25°C, ±1°C	
100 mV range	±(0.005% of reading +0.005% of range)
1V - 1000V range	±(0.005% of reading +0.001% of range)
6 months, 25°C, ±5°C	
100 mV range	±(0.008% of reading +0.005% of range)
1V - 1000V range	±(0.008% of reading +0.002% of range)
Temperature Coefficient:	
0 to 50°C	
100 mV range	±(0.001% of reading +0.001% of range)°C
1V - 1000V range	±(0.001% of reading +0.0003% of range)°C
Input Resistance:	
100 mV range	1,000 megohms
1V range	10,000 megohms min.
10V range	10,000 megohms min.
100 and 1000V ranges	10 megohms
Normal Mode Noise Rejection:	
(At or near line frequency)	
Filter In	74 dB (5000 to 1)
Filter Out	48 dB (250 to 1)
Common Mode Noise Rejection:	
Up to 1 kilohm in either lead:	
DC and at line frequency	120 dB minimum
Settling Time to 0.01% of Full Scale Step Input:	
Filter In	500 ms
Filter Out	25 ms

*Add .0005% of reading per 100 volts input signal

Table 1.1 - Specifications (Continued)

AC

Full Range Display:	1.00000, 10.0000, 100.000, 1000.00V rms
Overrange: 20% on all ranges Maximum Voltage Rating:	 500 volts to 10 kHz, decreasing linearly to 100V rms at 100 kHz
Resolution:	10 microvolts
Accuracy: 6 months, 25°C, ±5°C 50 Hz to 100 Hz 100 Hz to 5 kHz 5 kHz to 20 kHz 20 kHz to 100 kHz	 ±(0.25% of reading +0.10% of range) ±(0.10% of reading +0.02% of range) ±(0.50% of reading +0.05% of range) ±(2.00% of reading +0.10% of range)
Input Resistance: 1V range All other ranges	 2 megohms 1 megohm
Shunt Capacitance: With front input only With parallel rear input	 150 pF maximum 300 pF maximum
Common Mode Noise Rejection: Up to 1000 ohms in either lead: DC to 61 Hz	 60 dB
Settling Time to 0.1% of Full Scale Step Input:	2 seconds

DC/DC RATIO

Full Range Display:	±.100000:1, 1.00000:1, 10.0000:1, 100.000:1, and ±1000.00:1 (Readout is Ratio x 10)
Overrange:	20% on all ranges, ±1000 volts maximum input

Table 1.1 - Specifications (Continued)

DC/DC RATIO continued

Accuracy: 6 months, 25°C, +5°C		
.100000:1 range	±(0.008% r, +0.005% (10V/ref.) f.s.)	
.10000:1 to 100.000	±(0.008% r, +0.002% (10V/ref.) f.s.)	
Voltage Range:	Input Sig (Numerator)	Reference Sig (Denominator)
	0 to ±1000V	+2 to +12V
Input Resistance:		
.01:1 range	1,000 megohms	1 megohm
.1:1 range	10,000 megohms	1 megohm
1:1 range	10,000 megohms	1 megohm
10:1 and 100:1 ranges	10 megohms	1 megohm
Normal Mode Noise Rejection, Common Mode Noise Rejection, and Settling Time:	Same as DC specifications	

KILOHMS

Full Range Display:	.100000, 1.00000, 10.0000, 100.000, 1000.00 and 10000.0 kilohms	
Overrange: 20% on all ranges		
Fault Voltage:	Kilohm Range	Volts Peak
	1	30
	10	100
	100, 1000, and 10,000	300
Resolution:	10 milliohms	
Accuracy: 6 months, 25°C, ±5°C		
1, 10, 100 kilohm ranges	±(0.02% of reading +0.003% of range)	
1000 kilohm range	±(0.04% of reading +0.003% of range)	
10,000 kilohm range	±(0.25% of reading +0.003% of range)	

Table 1.1 - Specifications (Continued)

KILOHMS continued

Settling Time to 0.01% of Full Scale Step Input:	Kilohm Range	Time
	1, 10, and 100	.5 sec
	1000	1.5 sec
	10,000	3.0 sec
Current Through Unknown:	Kilohm Range	Current
	1	1 milliampere
	10	100 microamperes
	100	10 microamperes
	1000	1 microampere
	10,000	.1 microampere

GENERAL

Ranging:	Automatic or manual
Digitizing Technique:	Dual Slope Integrator
Integration Time:	100 ms
Digitizing Time:	220 ms maximum
Maximum Common Mode Voltage:	250 volts
Maximum Power Requirements: 25 watts, line voltage ± 10%	50 to 400 Hz
Operating Temperature:	0 to 50°C
Warm Up:	1/2 hour
Dimensions:	
Model 5330	17 x 3-1/2 x 14 inches or 43.2 x 8.9 x 35.6 cm.
Model 5370	8-1/2 x 7 x 14 inches or 21.6 x 17.8 x 35.6 cm.
Weight: (Approx)	15 pounds net, 20 pounds shipping
Guarantee:	12 months, faulty workmanship or component failure

SPECIAL NOTE

The shipping carton and its internal support structure have been scientifically designed for maximum protection of the instrument. Dana recommends saving the carton and contents for use in future reshipping of the instrument. Alternate packing methods, such as plastic foam blocks and loose packing material, may prove to be insufficient for maximum protection and result in damage during shipment.

If reshipping is required and the original carton is not available, special packing instructions can be obtained from Dana Labs' Product Service Department.

SECTION 2

INSTALLATION AND OPERATION

2.1 INPUT CONNECTIONS.

2.2 Signal input binding posts are located on the front of the accessory module. Connections to these terminals are made with standard "banana" plugs. Instruments designated by a "dash 1" (-1) following the model number are equipped with a duplicate set of input binding posts on the rear panel of the instrument.

2.3 INITIAL CHECKOUT PROCEDURES.

2.4 The shipping carton and its internal support structure have been scientifically designed for maximum protection of the instrument. Dana recommends saving the carton and contents for use in future reshipping of the instrument. Alternate packing methods, such as plastic foam blocks and loose packing material, may prove to be insufficient for maximum protection and result in damage during shipment. If reshipping is required and the original carton is not available, special packing instructions can be obtained from Dana Labs' Product Service Department.

2.5 The following procedure is performed to verify that no damage has occurred during shipment and that the instrument is operative. Slight deviations in readings during the following tests may be corrected by making simple adjustments. For instructions refer to Section 5, "Calibration". Any major discrepancies should be reported to the carrier and to Dana Laboratories immediately.

2.6 Prior to performing the checkout procedure, it is advisable to refer to the operating instructions in Section 3. Allow one-half hour for instrument to warm up before proceeding.

2.7 ZERO CHECK.

a. Select DC and auto range.

b. Short SIGNAL input leads. Visual readout should display .000000.

c. If necessary, adjust ZERO OFFSET control on front panel to obtain this reading.

2.8 POLARITY GAIN CHECK.

a. Select DC and 10 range.

b. Apply a known voltage of approximately 10 volts to the SIGNAL input. Visual readout should display value of input voltage (within specified tolerance) and proper polarity.

2.9 RANGE CHECK.

a. Select DC and 100 range.

b. Connect SIGNAL input to a source of +100 volts.

c. Visual readout should display input value (within specified tolerance) and proper polarity.

d. Vary input voltage and polarity; check for proper readout.

e. Repeat the above four steps on 1000-volt range.

f. Select Auto range and repeat the above checks.

2.10 AC CHECK (optional).

a. Select AC, autorange, and connect signal generator to SIGNAL input. Set generator to 50 Hz.

b. Check for proper readout (within specified tolerance) with each of the following input voltages applied: 9 volts, 90 volts, and 125 volts.

2.11 KILOHMS CHECK (optional).

a. Select Kilohms.

b. Check for proper readout (within specified tolerance) with each of the following resistances connected across the DMM input: 1K, 10K, 100K, 1 Meg, and 10 Megohm.

SECTION 3

OPERATION

3.1 CONTROLS.

3.2 OFF-ON-HOLD-Switch (on mainframe). This dual-purpose switch applies power to the instrument and allows the selection of HOLD.

a. OFF – All power is removed from the instrument.

b. ON – The instrument is operating and taking readings at 3.3 per second.

c. HOLD – Retains and displays the last reading of the instrument until it is switched back to the ON position.

3.3 RATIO X 10 Switch (on mainframe). This pushbutton switch, when depressed, removes the internal reference voltage from the measurement circuits and transfers to an external reference voltage applied at binding posts on the rear panel. The DMM then measures the ratio of the front-panel input to the reference voltage (+2 to +12V, applied at the rear panel, and the readout multiplied by E_{in}/E_{ref} X 10.

3.4 Controls on the Signal Conditioning Module are described in Table 3.1.

3.5 ZERO OFFSET.

3.6 ZERO OFFSET is adjusted as follows:

a. Select DC and AUTO RANGE.

b. Short SIGNAL input leads together.

c. Adjust for a readout of .00000.

3.7 ANALOG OUTPUT (OPTION 75).

3.8 With the Analog Output Option, binding posts on the rear panel deliver the d-c analog equivalent of the input (dc, ac, or ohms) at 10 volts full-scale, plus overrange. This output is for use with strip chart recorders, scopes, etc. Output current is 10 ma, maximum.

3.9 OPERATING INSTRUCTIONS.

3.10 For basic DC or AC measurement, a single-conductor shielded cable is used for interconnection between the signal source and the DMM. The conductor carries the high side of the signal and connects to the HIGH SIGNAL input terminal. The shield connects to the LOW SIGNAL input terminal which is strapped to GUARD (see figure 3.1).

CAUTION

Voltage applied between guard and the low-input terminal must not exceed 250 volts. Voltage applied between guard and the instrument case (Power line ground) must not exceed 500V. Voltage applied between the low-input terminal and the instrument case must not exceed 500V.

3.11 Where common-mode signals are present, a two-conductor shielded cable is required. Connections are made as shown in figure 3.2. The signal input terminals are isolated from the digital section and from power ground.

Table 3.1 - Operating Controls

FILTER (slide switch)	IN	Places an active three-pole filter into the circuit to provide additional noise rejection.
	OUT	Removes filter from circuit.
FUNCTION (pushbutton switches)	DC	Selects DC voltage measurements on full-scale ranges of .1V, 1V, 10V, 100V, and 1000V, plus overrange (maximum input: 1000V).
	AC	Selects AC voltage measurements on full-scale ranges of 1V, 10V, 100V, and 1000V, plus overrange (maximum input: 500V at frequency up to 10 KHz, decreasing to 100V above 100 KHz).
	KΩ	Selects resistance measurements on full-scale ranges of 1 Kilohm, 10 Kilohms, 100 Kilohms, 1 megohm, and 10 megohms.
RANGE (pushbutton switches)	AUTO	Selects autorange in which the optimum range is selected automatically by internal circuits. Uprange occurs at 100% of full-scale; downrange occurs at 10% of full-scale (approximately).
	.1, 1, 10, 100, 1000, 10000	Enables manual selection of fixed range. Ranges permissible for each function are identified on the panel.
OFF/ON/HOLD (Rotary switch on 5300 module)	OFF	Removes all power from the instrument.
	ON	Applies power to the instrument and enables periodic readings to be taken at the rate of 3.3 per second.
	HOLD	Retains and displays the last reading until switched back to ON position or externally commanded.

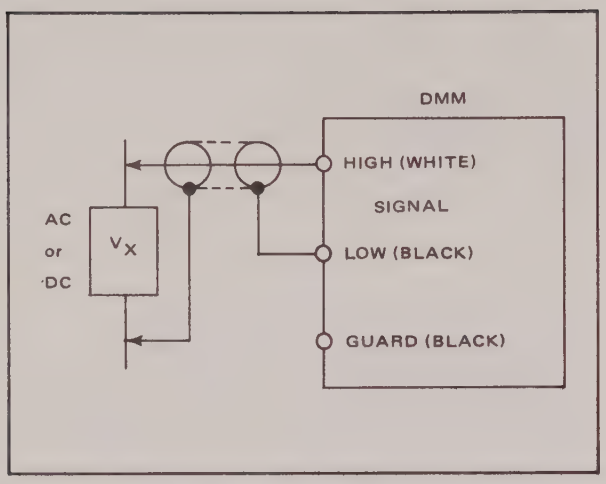


Figure 3.1 - Basic Measurement Connection

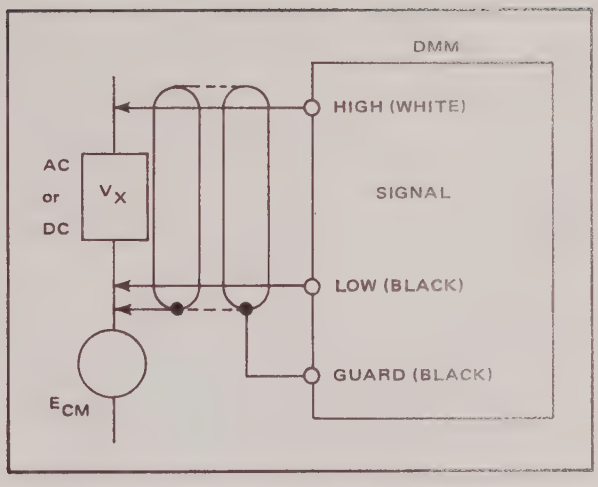


Figure 3.2 - Connections Where CM Present

3.12 DC/DC ratio measurement connections are made as shown in figure 3.3. The signal input can be on any d-c range and the same maximum input voltages apply. The reference voltage can be from +2V to +12V, dc. The readout displays E_{sig}/E_{ref} X 10. Signal and reference input leads are isolated from each other allowing true four-wire ratios.

3.13 Resistance measurements are made as shown in figure 3.4.

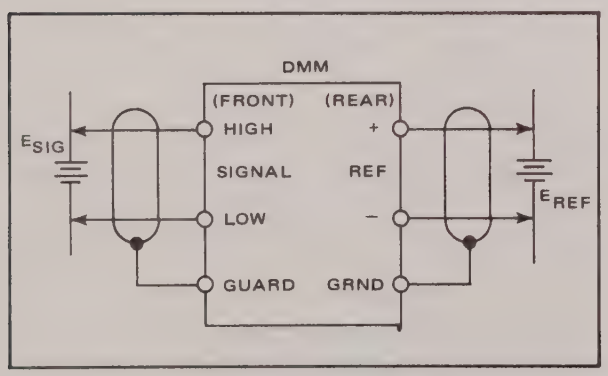


Figure 3.3 - DC/DC Ratio Connections (option 73)

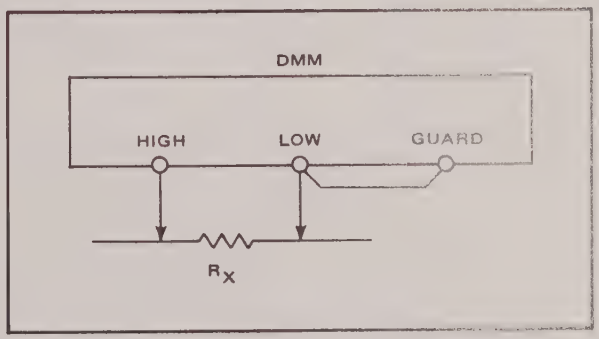


Figure 3.4 - Connections for Resistance Measurement

SECTION 4

THEORY OF OPERATION

4.1 INTRODUCTION.

4.2 The Signal Conditioning Module provides a 10-volt full-scale (12 volts with overrange) analog signal for measurement by the Digitizing and Display Module. The Isolator, range logic circuits and active filter are located on the main board. The AC and Ohms Converters are located on an optional second board which is mounted directly above the isolator board in the module. The output signal from the module may be either a positive or negative voltage when the unit is operating in the DC volts function. Polarity sensing is done in the Digitizing and Display Module. This section assumes the unit to be fully equipped with both AC and Ohms options. For instruments not fully equipped, disregard the appropriate section(s).

4.3 INPUT CIRCUITRY.

4.4 A dc input signal entering the DMM is applied to a relay controlled range divider, scaled, and then applied to the Isolator amplifier. The range divider consists of a set of matched resistors providing 100:1 voltage division. It is switched into the circuit only on DC and only on the 100 and 1000 ranges. A full-scale output of 10 volts from the Isolator is achieved for all ranges by changing the gain of the Isolator and/or switching the range divider.

4.5 An AC input signal is first applied to the AC Converter where it is scaled, rectified, filtered, and then applied to the Isolator.

4.6 For resistance measurements, the Ohms Converter generates a constant current applied through the unknown resistor. The voltage drop across the resistor is measured as a d-c voltage and applied to the Isolator.

NOTE

The partial schematics used in Section 4 are intended to describe operating principles only. Reference designators and component values in these schematics may differ from the complete schematics included in Section 6.

4.7 ACTIVE FILTER.

4.8 The filter (figure 4.1) is a three-pole RC active filter used in both AC and DC measurements. The circuit, a modified gaussian filter, provides a normal mode noise rejection of 60 dB at 60 Hz increasing 18 dB per octave to 80 dB.

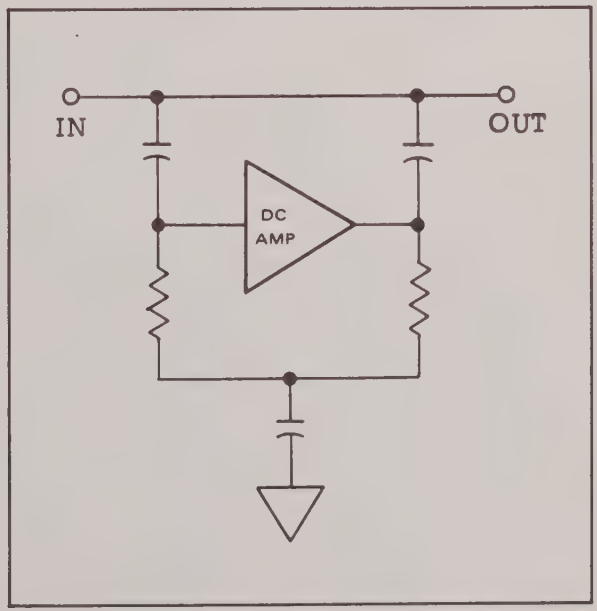


Figure 4.1 - Active Filter Block Diagram

4.9 FILTER OPERATIONAL AMPLIFIER.

4.10 The active element at the heart of the active filter is a DC amplifier. The feedback network around this DC amplifier is so connected that the circuit forms an operational amplifier with resistors R16 and R29 and capacitor C23 forming the feedback path. Capacitor C4 acts as the summing resistor (reactance).

4.11 The DC amplifier (figure 4.2) is a differential input amplifier having a single-ended output. The amplifier is connected between positive and negative voltage supplies, enabling its output to swing both positive and negative from zero. The first stage of the amplifier is a long-tailed pair composed of transistors Q4 and Q5. Only a single-ended output is taken from the input pair. This is taken from the collector of transistor Q4 which is the only one of the two input transistors provided with a collector load resistor. The second stage of the amplifier consists of the Darlington-connected pair of transistors Q6 and Q7. Resistor R21 provides the collector load for this stage. The output stage of the amplifier is composed of transistor Q8 with resistor R23 as its collector load. Zener diode CR10 in the emitter circuit of Q8 biases the emitter of Q8 5 volts away from the positive power supply yet provides a low dynamic impedance to AC signals. Diodes CR8 and CR9 across the bases of the input stage clamp the input voltage and never allow it to exceed ± 0.6V.

4.12 ISOLATOR (Schematic 430961).

4.13 The Isolator is a floating input potentiometric amplifier capable of operating at very low signal levels. Its output is a 10-volt full-scale analog

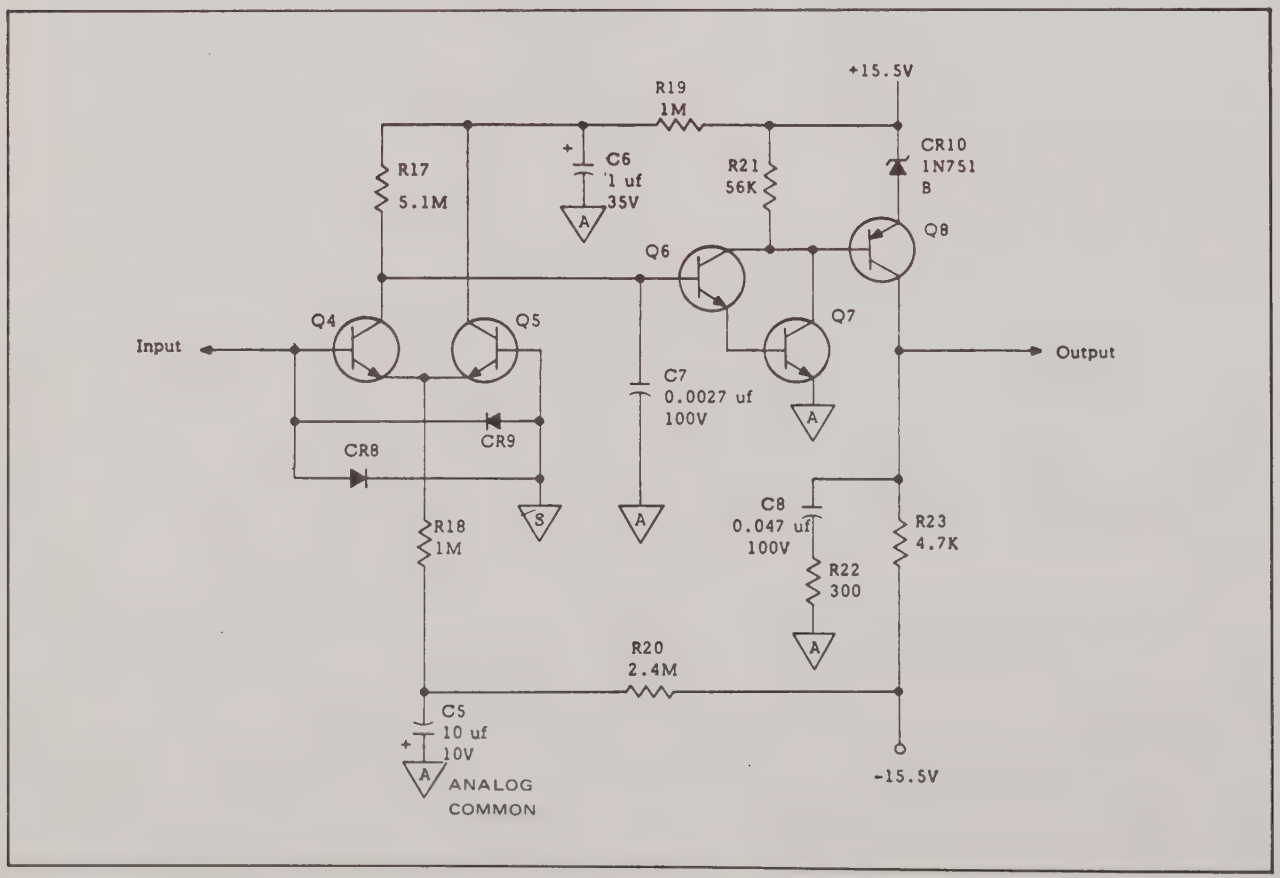


Figure 4.2 - Active Filter DC Amplifier

voltage (12 volts in overrange) that is applied to the Digitizing and Display module for measurement. The amplifier operates at a gain of one, ten, or a gain of one hundred, depending on the range and function to which the DMM is set (see table 4.1). The gain is switched by relays K2 and K3 that control a resistive divider in the feedback circuit when energized.

4.14 The isolator circuitry (figure 4.3) consists of two completely separate amplifiers, one that processes the signal and one that serves only to bootstrap the power supply feeding the front stages of the main amplifier. The output stage is a conventional complementary - symmetry type circuit which operates between the regular positive and negative supplies. The output stage is driven by transistor Q23, which also operates off the main plus and minus voltage sources.

4.15 Transistors Q15 and Q16 form positive and negative current generators which operate from the main positive and negative supply lines. Such current generators exhibit a characteristically high output impedance while providing a known and controlled flow of current through Zener diodes CR21 and CR22. The node where zener diodes CR21 and CR22 join together is connected to the output of the bootstrap amplifier. The bootstrap amplifier is a unity-gain amplifier whose input is connected to the inverting input of the first stage of the isolator amplifier. The neutral point of the zener supplies is thus driven by the bootstrap amplifier and is always at a voltage potential equal to that at the input of the bootstrap amplifier.

4.16 Since the Isolator is a high-gain closed-loop feedback amplifier, the error signal (potential difference) across its inputs (inverting and non-inverting input bases) is always very small and can in most practical cases be ignored. Therefore, the voltage at the inverting input to the Isolator (and at the input to the bootstrap amplifier) is always equal to the input voltage to the Isolator. The bootstrap amplifier, therefore, always drives the neutral node of the zener supplies to the same voltage as the input voltage to the isolator. The net effect is that the entire zener supply rides up and down on the two high impedance current generators. The voltages supplied to the first three stages of the Isolator are always 10 volts above and 7.5 volts below the input signal voltage, regardless of what the input signal voltage may be.

Table 4.1 - Range Logic

Range - Function	Range Logic	Divider	Isolator Gain	Relay Position		
				K1	K2	K3
0.1 DC	$\overline{R1}$ R2 $\overline{R3}$	1	100	Closed	Open	Open
1 DC	R1 $\overline{R2}$ $\overline{R3}$	1	10	Closed	Open	Closed
10 DC	$\overline{R1}$ R2 $\overline{R3}$	1	1	Closed	Closed	Open
100 DC	R1 R2 $\overline{R3}$	100	10	Open	Open	Closed
1000 DC	$\overline{R1}$ $\overline{R2}$ R3	100	1	Open	Closed	Open
AC all ranges		1	10	Closed	Open	Closed
1 Kilohm	R1 $\overline{R2}$ $\overline{R3}$	1	10	Closed	Open	Closed
10 Kilohms	$\overline{R1}$ R2 $\overline{R3}$	1	10	Closed	Open	Closed
100 Kilohms	R1 R2 $\overline{R3}$	1	10	Closed	Open	Closed
1000 Kilohms	$\overline{R1}$ $\overline{R2}$ R3	1	10	Closed	Open	Closed
10000 Kilohms	R1 $\overline{R2}$ R3	1	10	Closed	Open	Closed

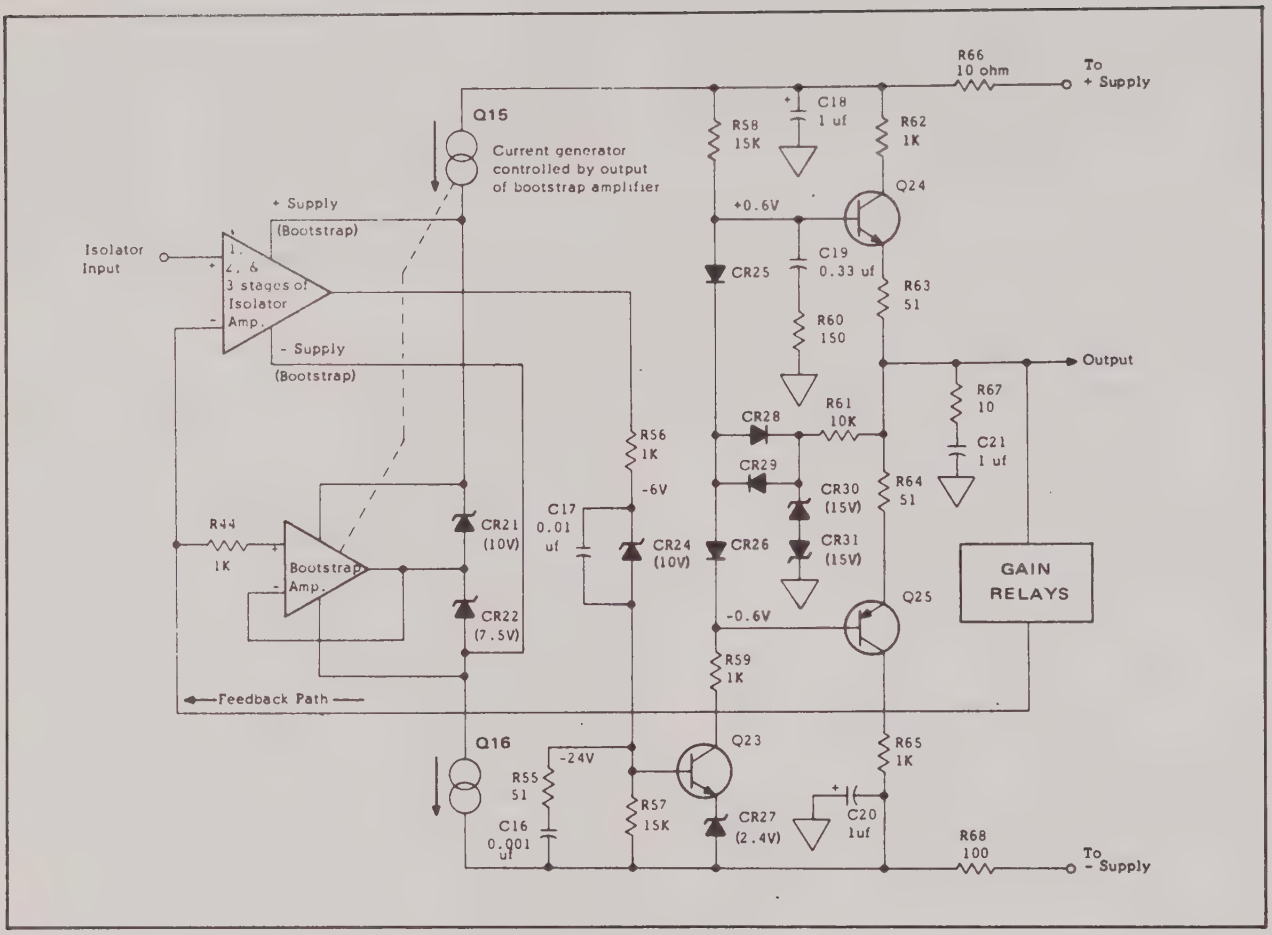


Figure 4.3 - Isolator

4.17 The input circuitry of the Isolator amplifier (figure 4.4) centers around transistor Q10 which is a dual NPN silicon transistor consisting of two separate transistors on a common substrate. Potentiometer R35, connected between the collector load resistors of the first stage, is the front panel zero adjustment potentiometer. Resistors R31 and R37 are factory selected to electrically center potentiometer R35. The error signal (voltage potential appearing between the bases of Q10) is clamped by back-to-back diodes CR17 and CR18 so that it can not exceed 0.6 volts. The input voltage is clamped by back-to-back zener diodes CR14 and CR15 so that it will not exceed approximately ± 13 volts. Diodes CR13 and CR16 compensate for slight leakage in the back-to-back zeners. Zener diodes CR11 and CR12 and resistor R27 prevent excessive voltage at the active filter node which would otherwise damage the filter capacitors. The input circuit of the Isolator can withstand an input overvoltage condition of up to 1000 volts for any length of time, without damage.

4.18 The network consisting of resistors R24, R25, R26, and R30 and transistor Q9 provides a temperature compensated, adjustable current source to bias the input base of the first stage. Potentiometer R26 is factory adjusted to schedule the optimum input current into the input base so that no current is taken from the circuit to which the DMM is connected. The biasing network is connected to the bootstrapped supply which is always referenced

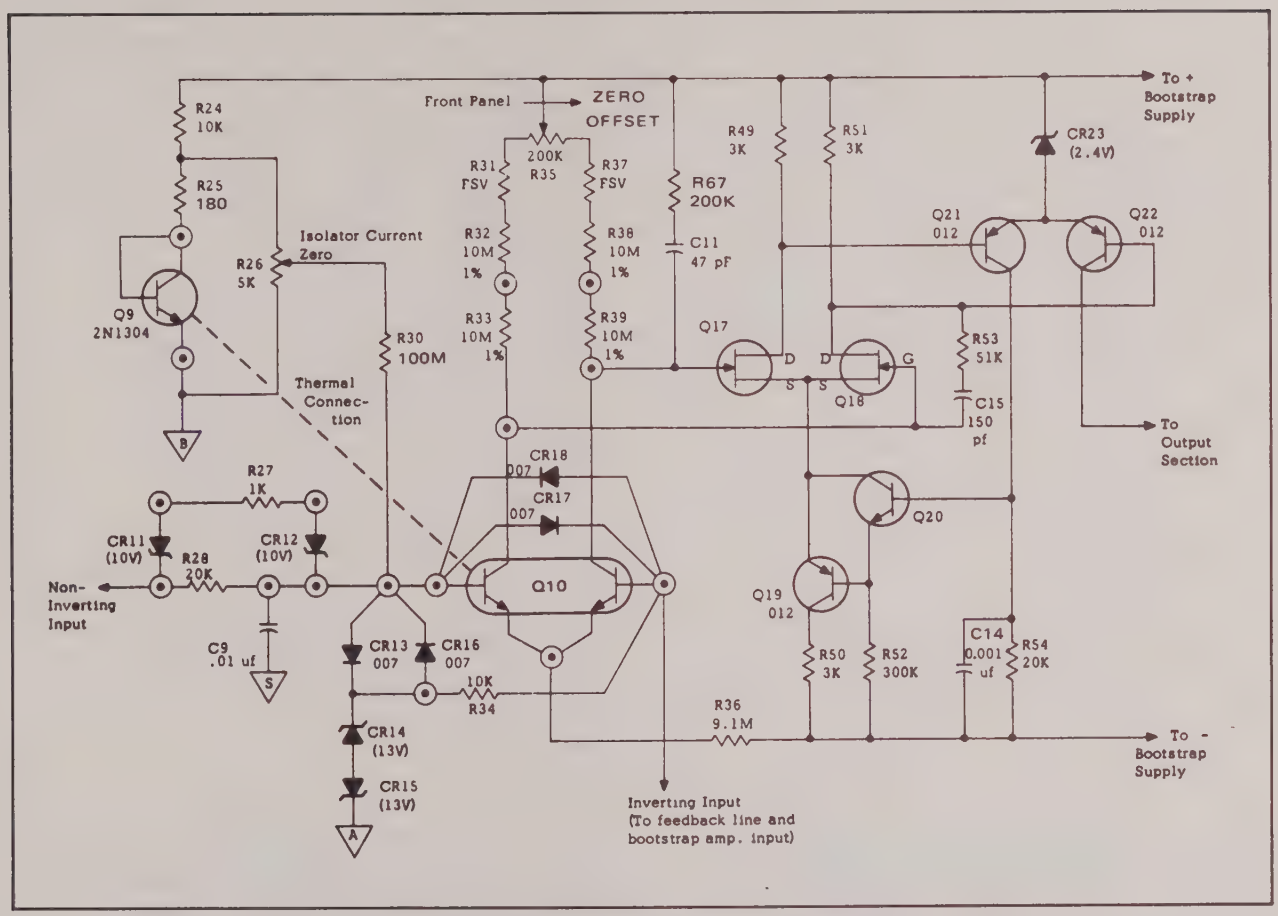


Figure 4.4 - Isolator Amplifier Input Circuitry

to the input signal thus achieving a high input impedance.

4.19 MODEL 50 AC CONVERTER.

4.20 With AC selected, the input is routed through the AC converter (figure 4.5) before entering the Isolator. All AC ranging is accomplished by the voltage divider network at the input of the AC converter. In the 1V range, relays K1, K2, and K3 are all open. The input signal is divided by the two 1 meg resistors R1 and R9. In the 10V range, relay K1 closes dividing the input signal by 20. In the 100V range relay K2 closes dividing the input signal by 200. In the 1000V range, relay K3 closes dividing the input signal by 2000. Thus the maximum voltage at the output of the input divider is always 0.6V (allowing for the 20% overrange feature) for any range. In cases where the DMM is manually locked in a low range and the full scale input voltage is exceeded, zener diodes CR3 and CR4 clamp the voltage at the output of the divider at ± 3V to prevent damage to input transistor Q1 and allow fast overload recovery. Diodes CR1 and CR2 compensate for slight leakages that exist in these zeners. Input capacitor C1 blocks any DC from entering the input divider.

4.21 The AC Converter is composed of two separate amplifiers. The input amplifier (A1 on figure 4.5) is a unity gain buffer amplifier having high input impedance and low output impedance. High input impedance is achieved through the use of a single N-channel field effect transistor at the input.

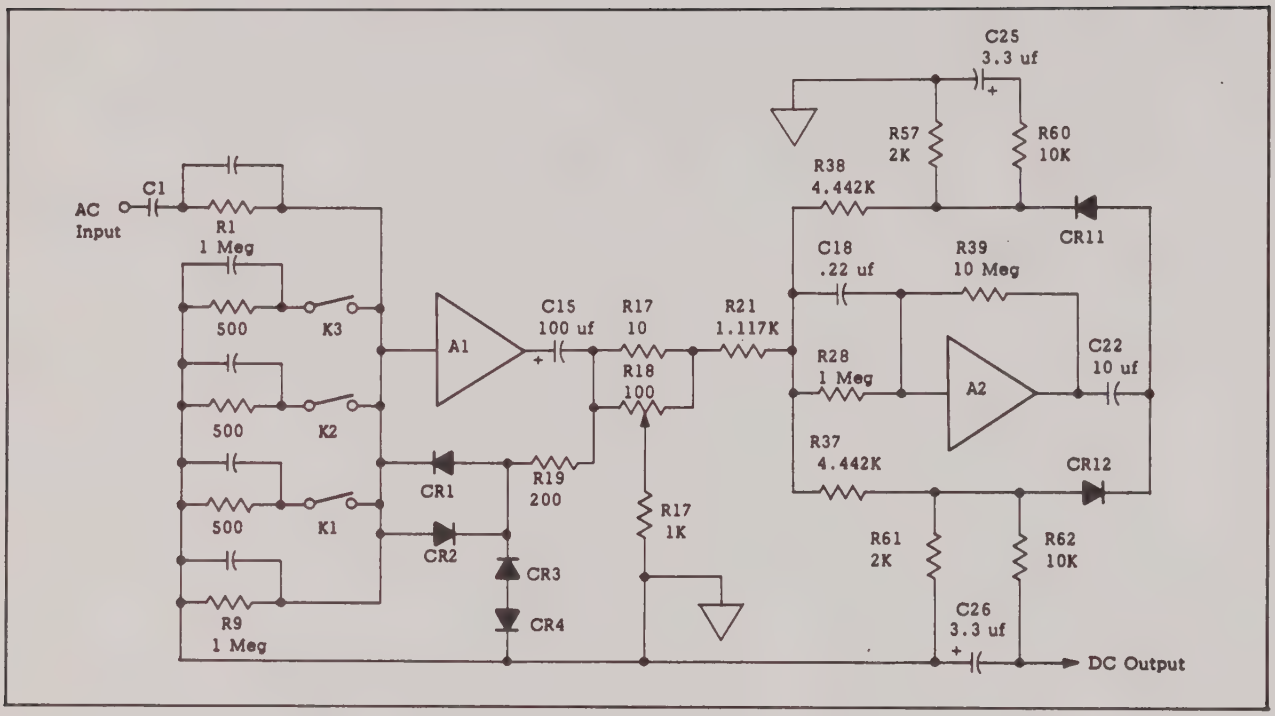


Figure 4.5 - AC Converter

4.22 The output amplifier (A2) is connected as an operational amplifier with resistor R38 or resistor R37 acting as the feedback resistor on alternate half cycles. Resistors R28 and R39 establish the DC gain of this amplifier at 10, thus providing DC stability. At all frequencies of interest, however, capacitor C18 presents an extremely low impedance in shunt with resistor R28. This means that the AC gain of the amplifier is essentially equal to the value of R21 divided into R38 (or R37) as shown in figure 4.6. Only the negative half-cycle of the rectified output is used. This is taken from the anode of diode CR12. Resistor R61 provides a proper load for diode CR12 and also provides a discharge path for capacitor C26. The rectified output is filtered by capacitor C26 across resistor R62 and is fed directly into the Isolator which is operating at a gain of 10.

4.23 Resistors R17 and R19 and potentiometer R18 form a simple adjustable voltage divider between amplifiers A1 and A2 to set the gain of the entire system. The 1V range is calibrated by adjusting R18 and must be calibrated first, before the other ranges. Capacitor C15 provides DC isolation between the output of A1 and the voltage divider.

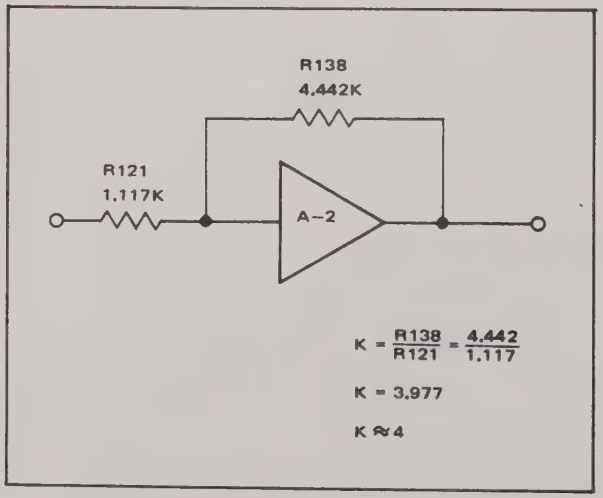


Figure 4.6 - AC Converter Output Section, Gain Determining Network

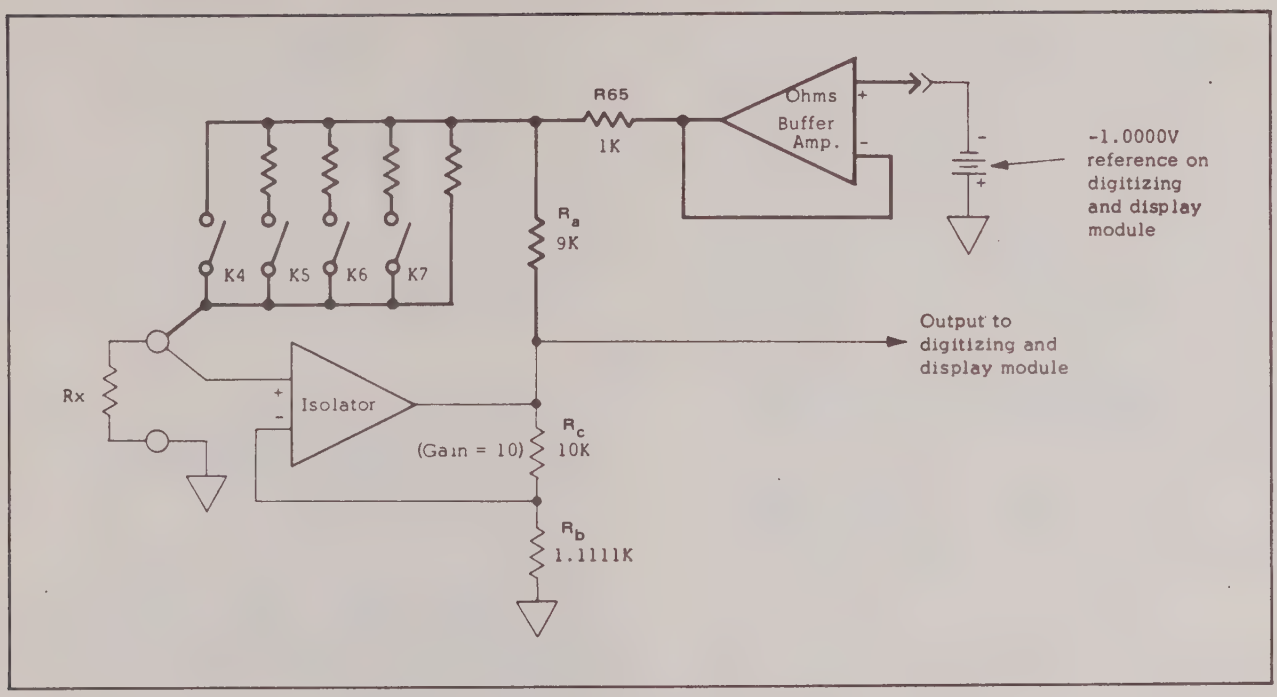


Figure 4.7 - Ohms Converter, Simplified

4.24 MODEL 60 OHMS CONVERTER.

4.25 When the Ohms function is selected, the Isolator is placed in a gain of 10 configuration just as is the case in the 1 volt DC range. In addition, the Ohms Converter is switched into the DMM's input circuitry. The Ohms Converter is shown in figure 4.7.

4.26 The ohms buffer amplifier is a unity gain amplifier capable of delivering one milliampere from its output. Its input is connected to the −1.0000 volt reference source located on the digitizing and display module. The output of this amplifier appears as a current source (of up to 1 ma) having a precise and constant output terminal voltage of 1.0000 volt. All output current from the ohms buffer amplifier flows through R65, a 1K ohm 0.01% precision resistor which limits the output current from the ohms buffer amplifier to 1 ma.

4.27 To demonstrate operation in the ohms measurement mode, assume that the 1000 Kilohm range is selected. Relay K4 is closed, so the other current limiting resistors need not be considered. Assume also that the 1-volt ohms current source is disconnected. The Isolator and its feedback network can now be shown as in figure 4.8. Resistors Rb and Rc represent the negative feedback network giving the Isolator a stable forward DC gain of 10. (Here Rb and Rc are shown as 1K and 9K, the same ratio as the actual values.) Resistors Ra and Rx form a positive feedback loop which offsets the stabilizing effect of Rb and Rc if Rx is very large. Resistor Rx represents the resistor being measured.

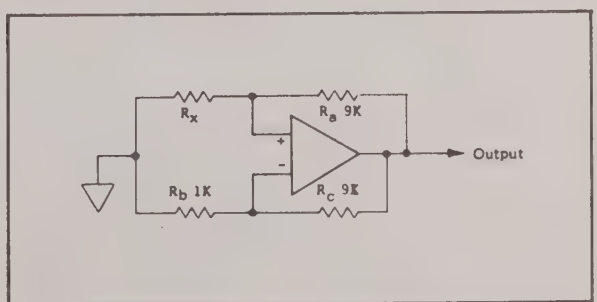


Figure 4.8 - Isolator Feedback Configuration in Ohms Mode

4.28 With Rx equal to zero ohms, Ra acts only as an additional 9K ohm load on the Isolator and has no feedback effect. Since the input node to the Isolator is grounded, its output is zero volts. With Rx increased to 1K ohms, the negative feedback stabilizing effect of Rb and Rc is exactly offset by the positive feedback effect of Rx and Ra. The output voltage of the Isolator may change in whatever direction circuit imbalances may "nudge" it. Whenever Rx is larger than 1K ohm, the positive feedback effect becomes proportionally stronger and the output voltage of the Isolator will lock against either the positive or negative power supply depending on which circuit imbalances provide the biggest "nudge".

4.29 With the 1-volt current source connected, the equivalent circuit is as shown in figure 4.9.

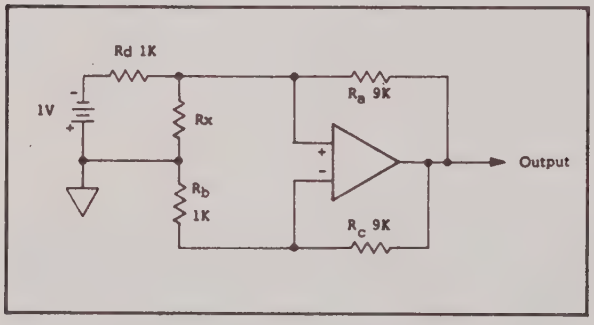


Figure 4.9 - Isolator Feedback With 1V Reference Supply Added

With Rx infinitely large (open circuit), the positive feedback effect of Ra predominates. The −1 volt source connected to the Isolator's input terminal provides a very powerful "nudge" and the output of the Isolator locks against its negative supply voltage. If Rx equals zero ohms, the input to the Isolator amplifier is grounded and its output is zero volts. For values of Rx between zero and 1200 ohms, the feedback circuit consisting of Ra, Rb, Rc, and Rx allow the output voltage of the Isolator amplifier to reach an equilibrium state somewhere between zero and −12 volts with the current through Rx always equal to 1 milliampere. The entire ohms measurement circuit can be represented as a current-stable bridge shown in figure 4.10.

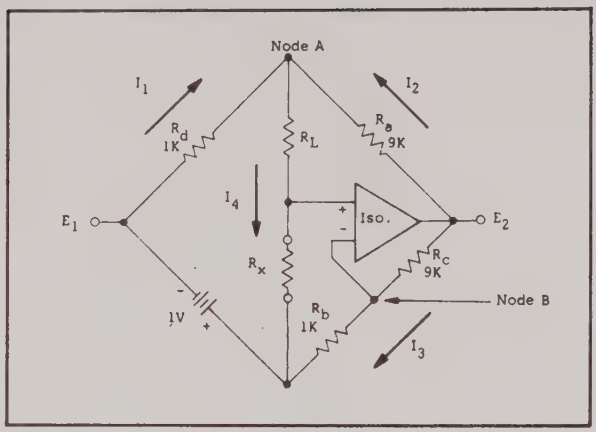


Figure 4.10 - Ohms Measurement Circuit Shown as a Current-Stable Bridge

4.30 Resistor R_L serves to limit the current through Rx on the higher ohms ranges. On the 1000 range (assumed in example), R_L equals zero ohms. Circuit action can be shown by picking values for Rx (between 0 and 1200 ohms) and analyzing circuit operation:

a. Assume Rx equals 100 ohms. Current flows from the 1 volt source through Rd and Rx into circuit common. The 1100 ohm series combination of Rd and Rx limits the current through Rx to 909 microamperes. The 909 microamperes flowing through Rx causes a voltage drop of −90.9 millivolts across it. The −90.9 millivolts across Rx produces an output of −.909 volts at the output of the Isolator amplifier due to the gain of 10 (produced by resistors Rb and Rc). Here the output voltage and current through Rx would remain were it not for the positive feedback effect afforded by resistors Ra and Rx. This causes the output voltage from the Isolator to continue to rise until the voltage at Node A exactly equals the voltage at Node B. (The output of an amplifier is stable only when its input error signal equals zero.) The rising output voltage from the Isolator pumps current into Node A through Ra causing the voltage at Node A to rise. This current is I_2 on figure 4.10. As the voltage at Node A rises, current I_1 decreases slightly. The equilib-

rium point is reached when the voltage at Node A exactly equals the voltage at Node B. This occurs when I_1 equals 900 microamperes, I_2 equals 100 microamperes, I_3 equals 100 microamperes and I_4 equals 1000 microamperes (1 milliampere). Voltage E_2, the Isolator output voltage, is equal to I_3 times (Rb + Rc). This is equal to −1.0000 volts which is displayed as 0.1000 kilohms on the DMM. 0.1 kilohms equals 100 ohms, the value of Rx.

b. If Rx is assumed to be 500 ohms, a similar effect takes place. Here the 1500 ohms in series with the 1 volt limits the initial current from the 1 volt source to 666 microamperes through Rx. This produces an initial terminal voltage across Rx of 333 millivolts which is bootstrapped by the positive feedback action of Ra and Rx to 500 millivolts. Here I_1 equals 500 microamperes, I_2 equals 500 microamperes, I_3 equals 500 microamperes and I_4 again equals 1 milliampere. The voltage at the output of the Isolator now equals I_3 x (Rb + Rc) which is −5.000 volts. The DMM displays 0.5000 kilohms. 0.5000 kilohms equals 500 ohms, the value of Rx.

4.31 On the higher ohms ranges, current limiting resistor R_L is inserted in series with Rx to limit the equilibrium current through it to a value that will result in a full scale IR drop across Rx of one volt on each range. The full scale current through Rx is shown in table 4.2 for each range.

Table 4.2 - Current Thru Unknown Resistors

Range	Current Through Unknown
1 Kilohm	1000 Microamps
10 Kilohm	100 Microamps
100 Kilohm	10 Microamps
1000 Kilohm	1 Microamp
10,000 Kilohm	100 Nanoamps

4.32 RANGE CONTROL.

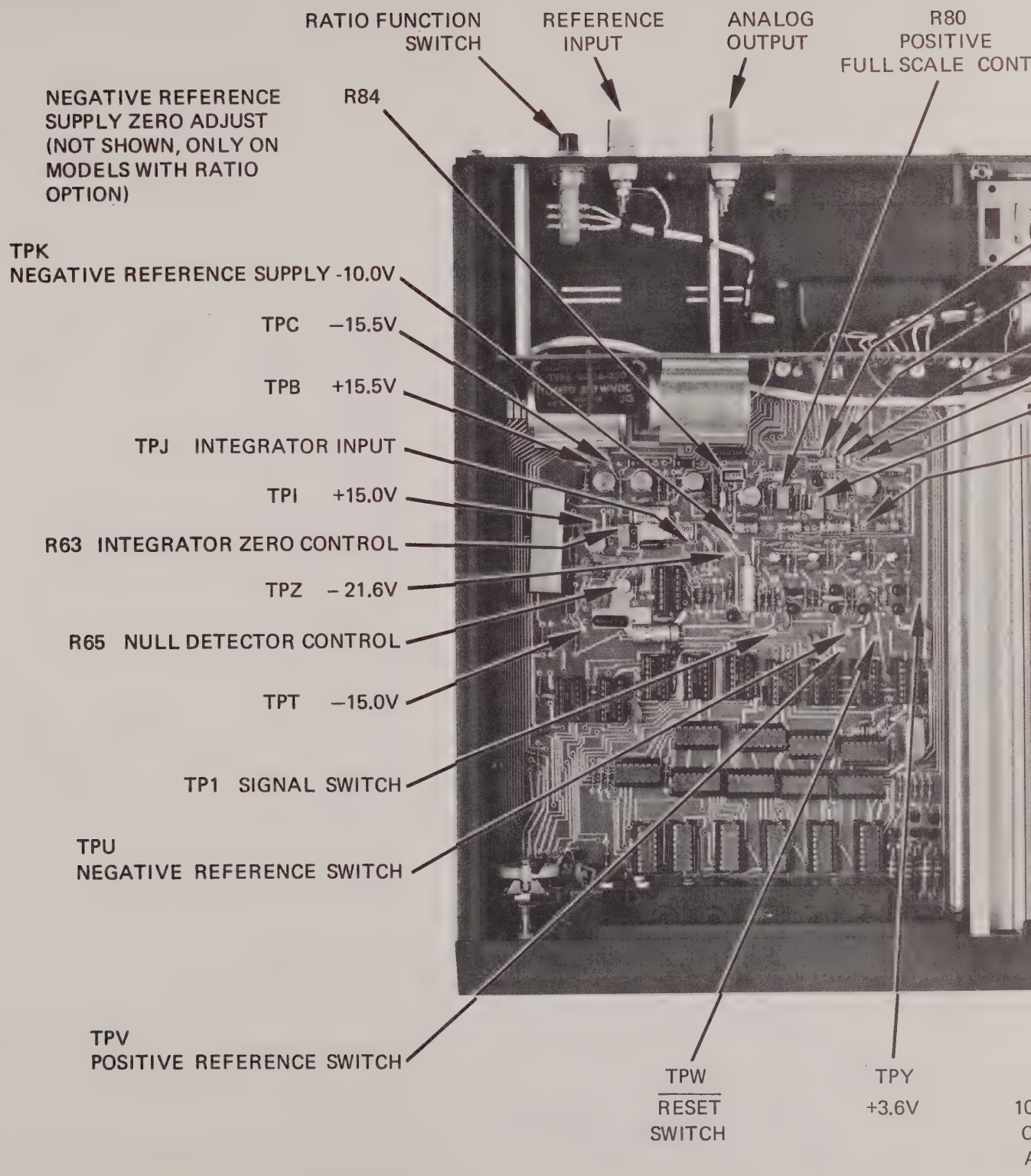
4.33 Ranging of the instrument is controlled by a three-stage flip-flop counter driven by control signals from the Digitizing and Display Module. The control signals are Up Range, Down Range, and Strobe.

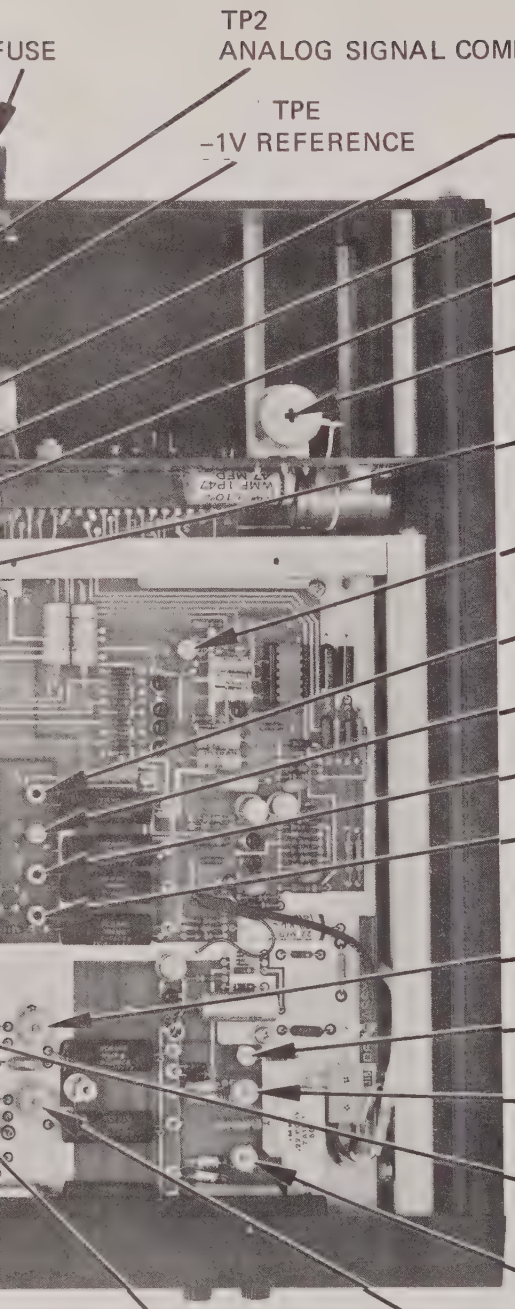
4.34 Up Range is true when the instrument is not on the highest range (1000 in volts or 10,000 in ohms) and the counter in the Digitizing and Display Module registers 120000 or higher. Down Range is true when the instrument is not in the lowest range (1 in AC/ohms and 0.1 in DC) and the counter in the Digitizing and Display Module registers 009999 or less. Strobe is true during the measurement period. The negative-going edge of this signal indicates the end of the measurement.

4.35 The range counter counts up or down in response to the Up Range and Down Range control signals. The state of the flip-flops corresponds to the codes and ranges listed in table 4.1. A manually selected range "forces" the flip-flops to the proper state by clamping the appropriate counter outputs to common.

4.36 A one-shot circuit provides a timeout (delay) of about 0.5 seconds at the end of a measurement period to allow time for ranging and for settling time of analog circuits. During this period, the HOLD line goes positive. This line is tied to the input of the control logic circuits in the Digitizing and Display Module where the positive level prevents a new reading from being taken.

4.37 When operating in a selected range, rather than autorange, the HOLD line is permanently strapped to common by the range switch and new readings are allowed during a range changing attempt.


RATIO FUNCTION SWITCH
REFERENCE INPUT
ANALOG OUTPUT
R80 POSITIVE FULL SCALE CONT
NEGATIVE REFERENCE SUPPLY ZERO ADJUST (NOT SHOWN, ONLY ON MODELS WITH RATIO OPTION)
R84
TPK NEGATIVE REFERENCE SUPPLY -10.0V
TPC −15.5V
TPB +15.5V
TPJ INTEGRATOR INPUT
TPI +15.0V
R63 INTEGRATOR ZERO CONTROL
TPZ − 21.6V
R65 NULL DETECTOR CONTROL
TPT −15.0V
TP1 SIGNAL SWITCH
TPU NEGATIVE REFERENCE SWITCH
TPV POSITIVE REFERENCE SWITCH
TPW RESET SWITCH
TPY +3.6V



FUSE

TP2
ANALOG SIGNAL COMMON

TPE
−1V REFERENCE

TPF EXTERNAL REFERENCE

TP3 ANALOG SIGNAL

R76 NEGATIVE FULL SCALE CONTROL

R8 +3.6V ADJUST

TPM PLUS REFERENCE SUPPLY +10.0V

R154 1 K OHM RANGE CALIBRATION CONTROL

R134 10,000 K OHM RANGE CALIBRATION CONTROL

R130 1000 KILOHM CALIBRATION CONTROL

R123 100 KILOHM RANGE CONTROL

R115 10 KILOHM RANGE CALIBRATION CONTROL

C110 10V AC RANGE, 10 kHz CONTROL

R118 1V AC 400 Hz CONTROL

C112 1V AC RANGE 10 kHz CONTROL

R107 10V AC RANGE 400 Hz CALIBRATION ADJUSTMENT

C103 1000V AC RANGE, 10 kHz CONTROL

R105
100V AC RANGE, 400 Hz CALIBRATION ADJUSTMENT

C108
100V AC RANGE, 10 kHz CONTROL

ANGE
ON
NT

Figure 5.1a

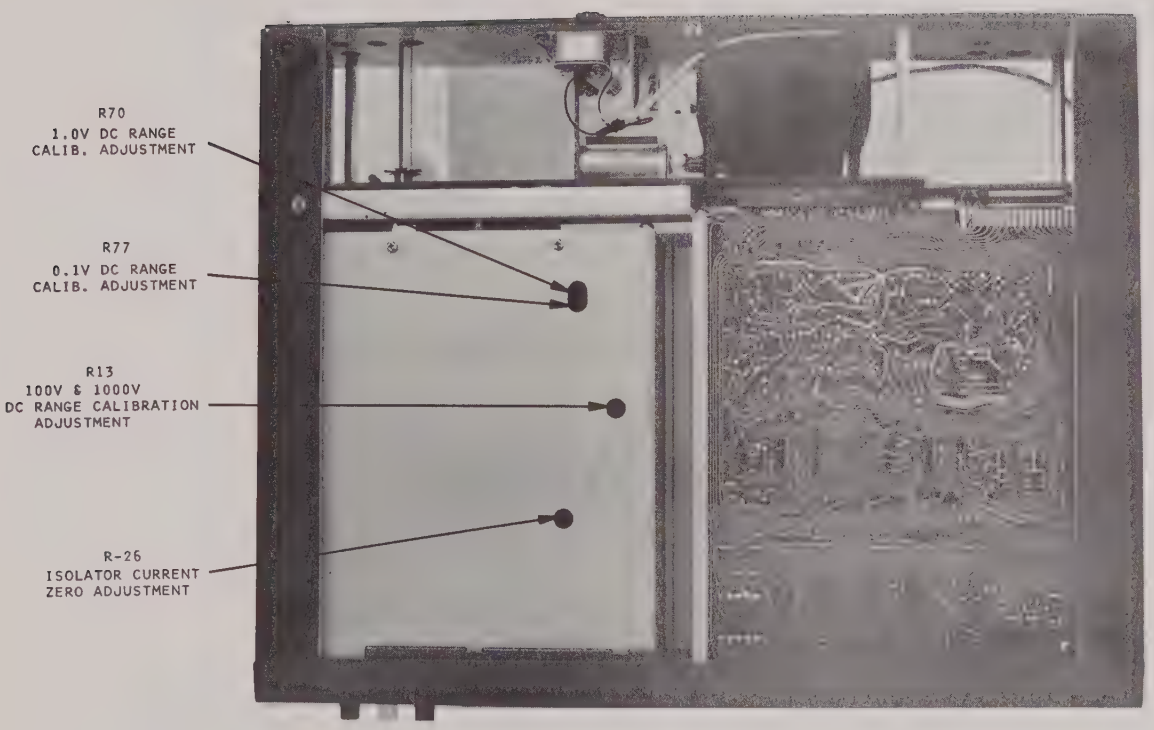

R70
1.0V DC RANGE
CALIB. ADJUSTMENT
R77
0.1V DC RANGE
CALIB. ADJUSTMENT
R13
100V & 1000V
DC RANGE CALIBRATION
ADJUSTMENT
R-26
ISOLATOR CURRENT
ZERO ADJUSTMENT

Figure 5.1b

SECTION 5

CALIBRATION

5.1 INTRODUCTION

5.2 This calibration procedure is designed to keep the model 5300/600 DMM operating within its specifications. Any necessary maintenance should be done prior to calibration. The calibration steps in this procedure rely on the adjusted accuracy of the preceding step, therefore care must be taken to make each adjustment in the order that it appears in this procedure.

5.3 EQUIPMENT REQUIRED

5.4 The following equipment, or an acceptable equivalent, is required for DMM calibration and is listed in the order of use. The test equipment specifications listed are recommended by Dana as necessary to give satisfactory calibration.

I. Basic DC Calibration of the Instrument

(a) A precision DC voltage standard (calibrator) variable from 0 to 1000 volts having a resolution of 100 microvolts or better at 10 volts (10 PPM), and an accuracy of .003% with a stability of .001%. For example, the Fluke model 332A or the Cohu model 351.

(b) A guarded absolute ratio voltbox capable of precision voltage division of 100:1, 10:1 and 1:1 with a resolution of ½ part per million. The input resistance should be 50 kilohms, minimum, at a ratio of 10:1 and 500 kilohms, minimum, at a ratio of 100:1. An ESI model 1040 A is recommended. (This instrument, when used in conjunction with the DC standard and a standard cell traceable to N.B.S., can normalize the DC standard to the traceable source).

(c) A precision decade voltage divider capable of 10:1 and 100:1 division, having an input resistance of 10,000 ohms minimum, an output resistance of 5000 ohms maximum, and an accuracy of .005% or better. For example, the ESI model RV-622A.

(d) A one megohm 5% carbon resistor.

II. AC Calibration (required only if the instrument has the AC option)

(a) An AC laboratory power source, variable from 0 to 500 volts and 50 Hz to 10 kHz, having a resolution better than 100 PPM, harmonic distortion of 0.1% or less and a stability of .01%. For example, the Optimation type AC 104, (oscillator, matching transformer, and power amplifier).

(b) An AC/DC laboratory transfer standard (for calibration of the AC source) having an accuracy of .05% or better. For example, the Holt Model 6 Thermal Transfer Voltmeter.

III. Ohms Calibration (required only if the instrument has the OHMS option.)

(a) Standard resistors: 1K, 10K, 100K, and 1 Megohm with value known to within .005%; and a 10 Megohm with value known to within .01%. For example, the ESI SR 1 series standard resistors.

5.5 TOOLS

(a) An insulated blade-type calibration tool.

(b) A No. 1 Phillips screwdriver.

5.6 PREPARATION

(a) Remove the two screws which secure the top and bottom covers of the instrument. Slide (only) the top cover back and remove it.

(b) Set the DMM controls as follows:

Function: DC volts
Range: Auto
Ext Ref Switch (on rear panel): Out (if applicable)

(c) Set the OFF-ON-HOLD switch on the front of the instrument to the ON position.

(d) Connect the GUARD terminal on the front of the instrument to the LO input terminal. Connect a test lead to the HI (only) input terminal of the instrument.

5.7 POWER SUPPLY CHECK (Refer to Figure 5.1)

(a) Using the test lead installed in the preceding step (5.6-d), the instrument can measure its own operating voltages at the four test points listed below. If any of the voltages do not measure within the tolerances indicated the defective power supply must be repaired before any further calibration is attempted. (NOTE: The uncalibrated accuracy of the instrument is normally adequate for measuring these voltages within the specified limits unless the unit in need of repair.)

Test Point	Voltage
I	+15 volts ± 10%
Z	-21.6 volts ± 10%
T	-15 volts ± 10%
Y	+3.6 volts ±0.1 volt (If not within tolerance, adjust potentiometer R-8 on the Power Supply Module to set the voltage to +3.6 volts)

(b) Remove the test lead from the "HI" input terminal.

(c) Short the "HI" and the "LO" input terminals of the instrument together. (NOTE: This clip lead must use plain, unplated copper clips. Cadmium plated clips act like thermocouples, generating enough voltage to cause several digits of zeroing error in some cases.)

(d) Replace the top cover on the unit and allow at least 30 minutes for the instrument to reach a stable internal ambient operating temperature.

5.8 ANALOG ZERO ADJUSTMENT

(a) With the two input terminals jumpered together, place the instrument (manually) in the 10 volt DC range. Carefully note the reading indicated on the instrument's readout.

(b) Now place the instrument in the 0.1 volt DC range and adjust the ZERO OFFSET potentiometer on the front of the Signal Conditioning Module to obtain a reading within ± 1 digit of the reading noted in step "a" above.

5.9 INTEGRATOR ZERO ADJUSTMENT

(a) Jumper the input terminals together on the front panel. Place the DMM in the DC Function and the 10 Range. Allow the DMM five minutes warm up.

(b) Slide the top cover to the rear of the DMM to expose the Integrator Zero Adjustment Control R-63. Refer to figure 5.1a for location.

(c) Adjust the Integrator Zero Control R-63 such that the Polarity Indicators are alternately displaying plus and minus.

(d) Remove the short between the "High" and "Low" Input Terminals.

(e) Connect the test equipment and the instrument under calibration as shown in figure

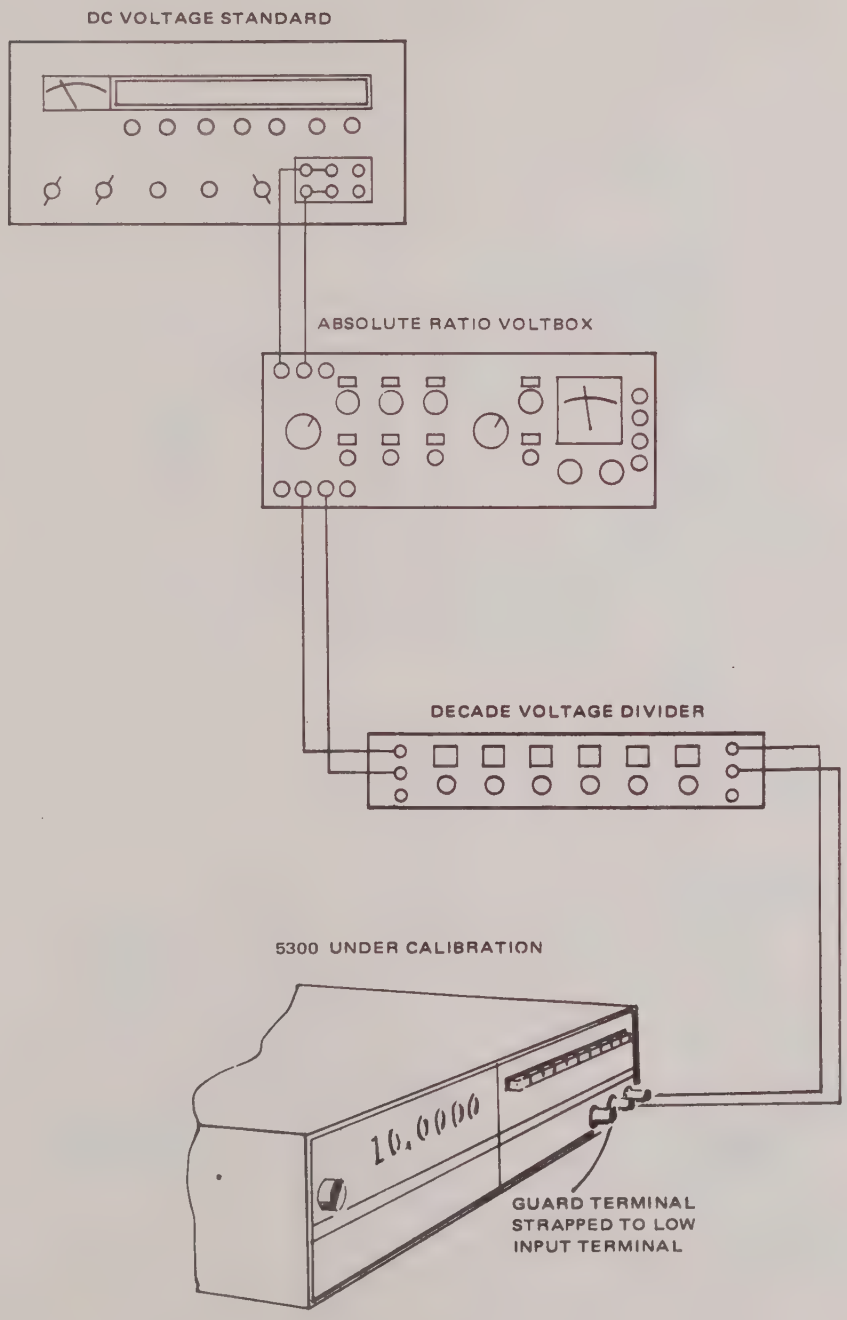


Figure 5.2 - Setup for calibration of lower DC voltage ranges

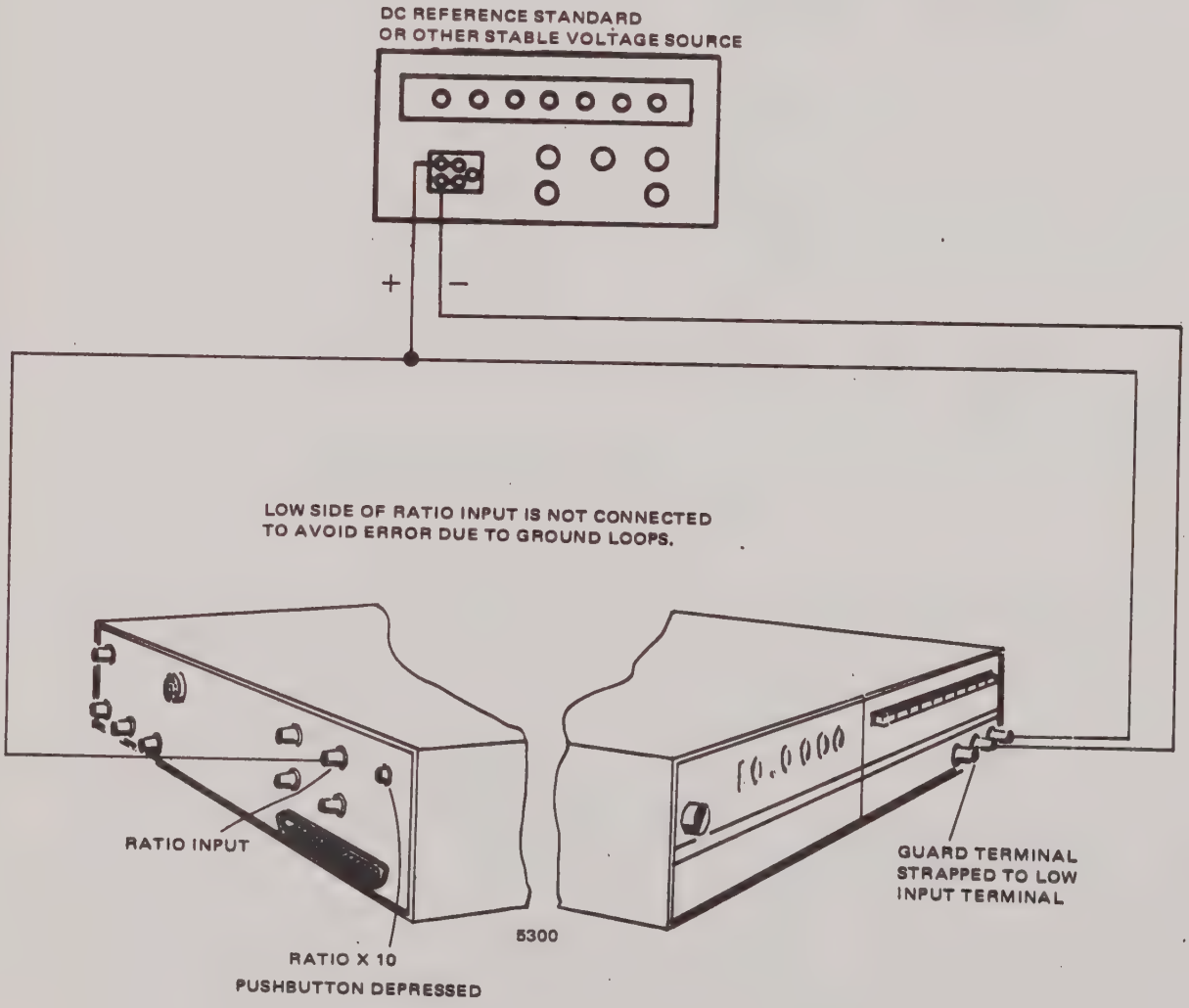


Figure 5.3 - Ratio measurement accuracy test setup

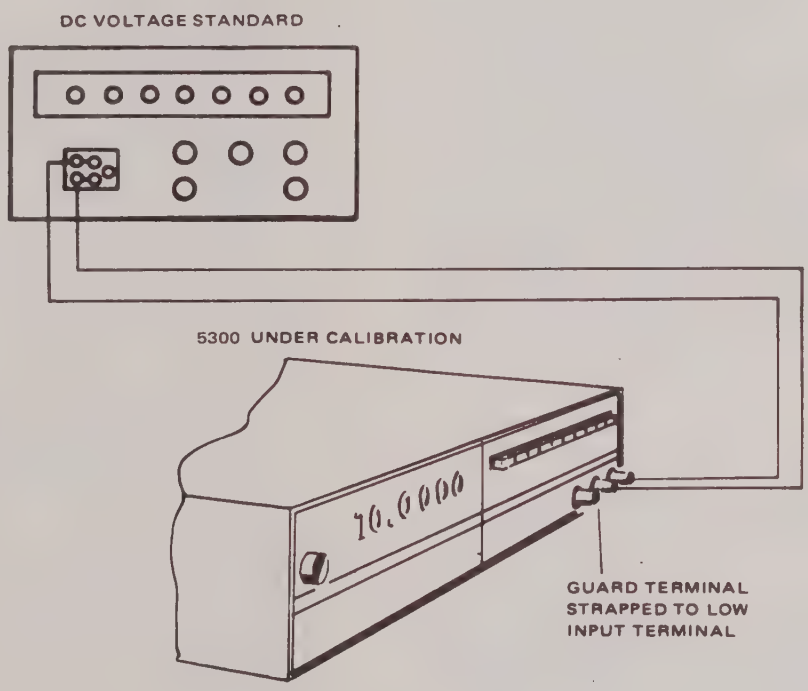


Figure 5.4 - Setup for 100V and 1000V DC range calibration

5.2. Connect the test leads from the decade voltage divider to the DMM. Connect the input voltage to the DMM with the negative tied to the "High" Input Terminal of the DMM.

(f) Apply an input voltage of -0.001 VDC to the DMM. Note the reading. Apply an input voltage of +0.001 VDC. Note the second reading and compare with the first reading. If the adjustment of the integrator zero control is correct the voltage in both cases will be the same but the polarity will change with the input polarity. Adjust the Null Detector Control (R65) on the display board for a display of 10 digits or 1 millivolt. Verify that the DMM reads + or − 1 millivolt with the signal on the input. Also verify that the DMM displays alternately plus and minus and all zeros with the input shorted. If necessary, repeat steps 5.9 (a) thru (f).

5.10 VOLTAGE CALIBRATION OF THE DIGITIZING AND DISPLAY MODULE (Refer to Figure 5.1.)

(a) Set the absolute ratio voltbox to 1.0 (1:1). Set the decade voltage divider to .999999. This applies an input signal of -9.99999 volts to the DMM.

(b) Slide the top cover of the instrument back just enough to expose potentiometer R-76 (negative full scale adjustment potentiometer).

(c) Adjust R-76 so that the indication on the readout is -10.0000.

(d) Slide the top cover forward over the instrument.

(e) Reverse the polarity of the input signal so that it is now +9.99999 volts.

(f) Slide the top cover of the instrument back just enough to expose potentiometer R-80 (positive full scale adjustment potentiometer).

(g) Adjust R-80 so that the readout is +10.0000.

(h) Slide the top cover forward over the instrument and wait a minimum of five minutes to allow the internal temperature to re-stabilize.

(i) Verify that the indication on the instrument's readout will still read +10.0000 with an input signal of 9.99999 volts. Similarly verify that the reading will read -10.0000 with an input 9.99999 volts. If necessary, repeat the adjustments of R-76 and R-80 outlined in steps 5.10-a through 5.10-h to obtain the specified readings.

5.11 LINEARITY TEST (NOTE: There are no adjustments to be made in section 5.11. These tests are included to verify the overall accuracy of the instrument up to this point.)

(a) Set the DMM controls as follows:

Function: DC
Range: 10
Ratio X10 Switch (on rear panel): Out (if applicable)

(b) Verify the DMM readout for the following input voltages:

Voltage Input	DMM Readout
-11.9950	-11.9950 ± 5 digits
-10.0000	-10.0000 ± 5 digits
- 9.0000	-09.0000 ± 5 digits
- 8.0000	-08.0000 ± 5 digits
- 7.0000	-07.0000 ± 5 digits
- 6.0000	-06.0000 ± 5 digits
- 5.0000	-05.0000 ± 5 digits
- 4.0000	-04.0000 ± 5 digits
- 3.0000	-03.0000 ± 5 digits
- 2.0000	-02.0000 ± 5 digits
- 1.0000	-01.0000 ± 5 digits
0.0000	+00.0000 ± 5 digits

(c) Reverse the polarity of the input to the DMM and verify the readout for the following input voltages:

Voltage Standard Input	DMM Readout
0.0000	+00.0000 ± 5 digits
+ 1.0000	+01.0000 ± 5 digits
+ 2.0000	+02.0000 ± 5 digits
+ 3.0000	+03.0000 ± 5 digits
+ 4.0000	+04.0000 ± 5 digits
+ 5.0000	+05.0000 ± 5 digits
+ 6.0000	+06.0000 ± 5 digits
+ 7.0000	+07.0000 ± 5 digits
+ 8.0000	+08.0000 ± 5 digits
+ 9.0000	+09.0000 ± 5 digits
+10.0000	+10.0000 ± 5 digits
+11.9950	+11.9950 ± 5 digits

NOTE: If the instrument is not within the tolerance indicated in the above tests, the adjustments in sections 5.8 through 5.10 must be rechecked for error. If this does not correct the problem, the instrument is in need of repair.

(d) Disconnect the DMM from the voltage standard.

5.12 TEST OF THE "RATIO" MEASUREMENT ACCURACY (NOTE: If the instrument is not equipped with the optional RATIO feature, disregard this section and proceed to Section 5.13).

(a) Connect the instrument to a stable source of approximately 10 volts as shown in figure 5.3. (10V ± 10%).

(b) Place the instrument in the "ratio" function by pressing the RATIO X10 pushbutton located on the rear panel.

(c) Place the instrument in the 10 volt DC range.

(d) Verify that the readout indicates 10.0000 ± 6 digits.

(e) Adjust the voltage of the stable voltage source to approximately one volt. (1V ± 10%)

(f) Verify that the readout indicates 10.0000 ± 25 digits. If not, short the ratio input and connect a microvoltmeter from TP-K to common. Adjust R84 for a minimum reading of less than 30 microvolts.

NOTE: After R84 is adjusted, recheck the adjustments called out in paragraphs 5.8 through 5.10.

(g) Switch the RATIO X10 pushbutton to "out" and disconnect the reference and signal input leads from the instrument.

5.13 ADJUSTMENT OF ANALOG CURRENT ZERO (Refer to Figure 5.1.)

(a) Place the instrument on its side in a manner such that the adjustment potentiometers located on the bottom side of the Signal Conditioning Module can be adjusted when the bottom cover has been slid back far enough to expose them. Leave the bottom cover in place at this time.

(b) Place the instrument in the DC VOLTS function and manually select the lowest range.

(c) Connect a 1 Megohm 5% carbon resistor across the input terminals of the instrument by loosening the binding posts, placing the resistor leads through the binding post holes and tightening the binding posts on the resistor leads.

(d) Connect a short clip lead across the input terminals of the instrument. (NOTE: This clip lead must use plain, unplated copper clips. Cadmium plated clips act like thermocouples, generating enough voltage to cause several digits of zeroing error in some cases.)

(e) Adjust the front panel ZERO OFFSET potentiometer for a reading of +.000000.

(f) Remove the clip lead.

(g) Slide the bottom cover of the instrument back just enough to expose potentiometer

R-26 (the Isolator Current Zero potentiometer).

(h) Adjust R-26 to obtain a reading of .000000 ± 15 digits.

(i) Re-check steps d through h above to eliminate any interaction.

(j) Remove the 1 Megohm resistor from the DMM input terminals.

5.14 DC VOLTAGE CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.3.)

(a) Connect the test equipment and the instrument under calibration as shown in figure 5.2. Set all dials on the voltage standard and decade voltage divider to zero.

(b) Set the DMM controls as follows:

Function: DC Volts
Range: Auto
Ratio X10 Switch (rear panel): Out (if applicable)

(c) Verify that the DMM readout indicates all zeros and "bounces" between + and - polarity indicators. If necessary adjust the ZERO OFFSET potentiometer on the front of the instrument.

(d) Set the DC voltage standard to -10.0000 volts.

(e) Set the absolute ratio voltbox to X.01 (100:1).

(f) Set the decade voltage divider to .9999990.

(g) Slide the bottom cover of the instrument back just enough to expose the calibration potentiometers on the bottom of the signal conditioning module.

(h) Adjust potentiometer R-77 (the 0.1 volt adjustment potentiometer) so that the indication on the readout is -.100000.

(i) Set the absolute ratio voltbox to X.1 (10:1).

(j) Adjust potentiometer R-70 (the 1V DC range calibration potentiometer) so that the indication on the readout is -1.00000.

(k) Set the absolute ratio voltbox to X.01 (100:1) or disconnect it from the DC voltage standard.

(l) Connect the DMM input directly to the DC voltage standard as shown in figure 5.4.

(m) Adjust the output of the DC voltage standard to -99.9999 volts.

(n) Adjust potentiometer R-13 (the 100 and 1000 volt adjustment potentiometer) so that the indication on the readout is -100.000.

(o) Adjust the output of the DC voltage standard to zero volts.

(p) Slide the bottom cover of the instrument forward into place and set the instrument in an upright position. Allow five minutes for the operating temperature of the instrument to re-stabilize.

(q) Verify the accuracy of each range by following the tests in table 5.1.

Table 5.1

Set DC Voltage Standard To	Instrument Readout Should Indicate
+1000.00 volts	+1000.00 ± 2 digits[1]*
+100.000 volts	+100.000 ± 2 digits[1]
+10.0000 volts	+10.0000 ± 2 digits[2]
+1.00000 volt	+1.00000 ± 2 digits[1]
+.100000 volt[3]	+.100000 ± 2 digits[1]
- .100000 volt[3]	- .100000 ± 2 digits[1]
- 1.00000 volt	- 1.00000 ± 2 digits[1]
- 10.0000 volts	- 10.0000 ± 2 digits[2]
- 100.000 volts	- 100.000 ± 2 digits[1]
- 1000.00 volts	- 1000.00 ± 2 digits[1]

*Notes on following page

NOTES:

1) If the DMM readout is not within the specified accuracy, re-check the adjustments outlined in Section 5.14.

2) If the DMM readout is not within the specified accuracy, re-check the adjustments outlined in Section 5.10.

3) It is necessary to use a 10:1 voltage divider out of the DC voltage standard to reduce noise and increase accuracy.

(r) Remove the DMM input leads from the DC voltage standard

(s) Reduce the output voltage of the DC voltage standard to zero volts.

5.15 AC VOLTAGE CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.1).

(NOTE: If the instrument is not equipped with the optional AC feature, disregard this section and proceed to section 5.16.)

(a) Set the DMM controls as follows:

Function: AC volts
Range: Auto
Range X10 Switch (on rear panel): Out (If applicable)

(b) Connect the DC voltage standard, thermal transfer voltmeter, AC laboratory source, and the DMM under calibration, as illustrated in Figure 5.5.

NOTE: There are eight distinct steps in the calibration of the AC Converter. They must be performed in sequence. All eight steps are shown in table 5.2. Sections 5.15-c through 5.15-h, which follow, give detailed instructions on how to perform step one. The remaining steps (2 through 8) are simply repeats of the same process at different voltages and frequencies and adjusting different controls. These differences are listed in table 5.2.

(c) Switch the thermal transfer voltmeter to DC input.

Table 5.2 - Sequence of adjustments required for AC converter calibration

Step	AC Input Voltage	Signal Frequency	Adjust	Readout Should Indicate	Remarks
1	1.00000V	400 Hz	R118	.99990 to 1.00010	1V Low Frequency
2	500.00V	400 Hz	R103	499.90 to 500.10	1000V Low Freq.
3	500.00V	10 kHz	C103	499.90 to 500.10	1000V High Freq.
4	1.00000V	10 kHz	C112	.99990 to 1.00010	1V High Freq.
5	10.0000V	400 Hz	R107	9.9990 to 10.0010	10V Low Freq.
6	10.0000V	10 kHz	C110	9.9990 to 10.0010	10V High Freq.
7	100.000V	400 Hz	R105	99.990 to 100.010	100V Low Freq.
8	100.000V	10 kHz	C108	99.990 to 100.010	100V High Freq.

(NOTE: Other techniques using an AC calibrator or a standardized digital voltmeter will perform this calibration procedure equally as well. Figure 5.6 illustrates the use of a Dana model 5700 DVM as the standardized digital voltmeter in such an application. This arrangement provides a direct reading capability.)

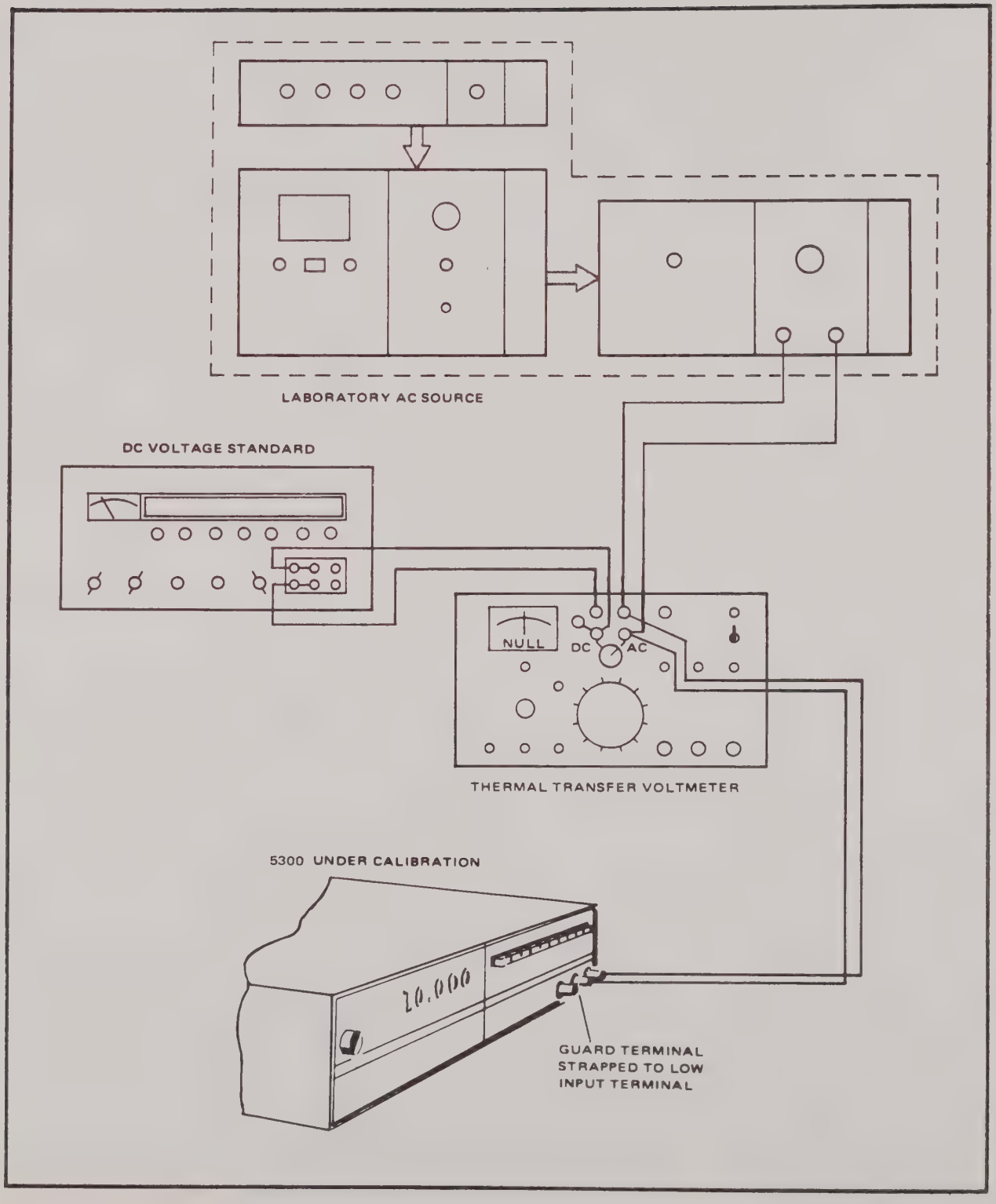


Figure 5.5 - Setup for AC calibration

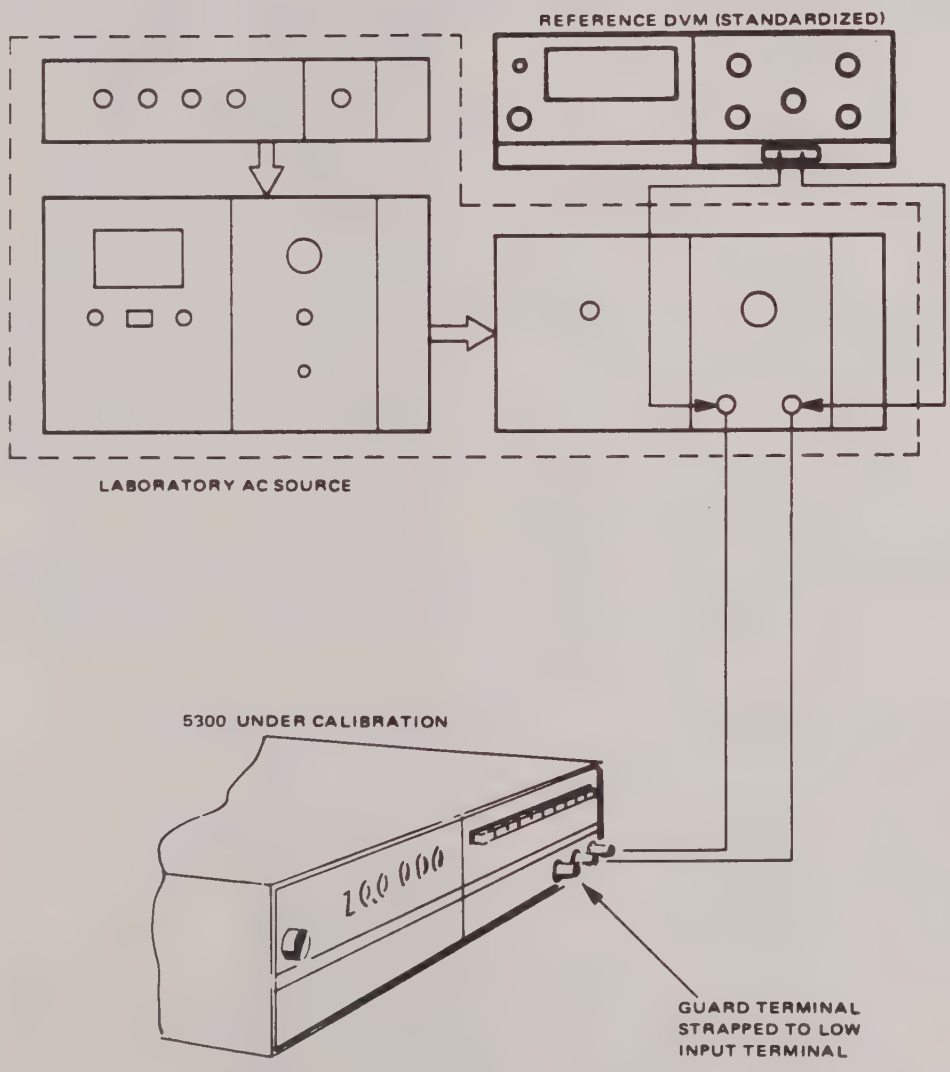


Figure 5.6 - Alternate setup for AC calibration

Table 5.3 - Allowable error in digits in AC volts function

If the Input Signal, on any given range, is:	The maximum number of digits error from 50 Hz to 100 Hz is:	The maximum number of digits error from 100 Hz to 5 kHz is:	The maximum number of digits error from 5 kHz to 20 kHz is:	The maximum number of digits error from 20 kHz to 100 kHz is:
0% of full scale (Input shorted)	± 100 digits	± 20 digits	± 50 digits	± 100 digits
10% of full scale	± 130 digits	± 30 digits	± 100 digits	± 300 digits
20% of full scale	± 150 digits	± 40 digits	± 150 digits	± 500 digits *
30% of full scale	± 180 digits	± 50 digits	± 200 digits	± 700 digits
40% of full scale	± 200 digits	± 60 digits	± 250 digits *	± 900 digits
50% of full scale	± 230 digits *	± 70 digits *	± 300 digits	± 1100 digits
60% of full scale	± 250 digits	± 80 digits	± 350 digits	± 1300 digits
70% of full scale	± 280 digits	± 90 digits	± 400 digits	± 1500 digits
80% of full scale	± 300 digits	± 100 digits	± 450 digits	± 1700 digits
90% of full scale	± 330 digits	± 110 digits	± 500 digits	± 1900 digits
100% of full scale	± 350 digits	± 120 digits	± 550 digits	± 2100 digits
110% of full scale	± 380 digits	± 130 digits	± 600 digits	± 2300 digits
120% of full scale	± 400 digits	± 140 digits	± 650 digits	± 2500 digits

*Refer to Table 5.4. Maximum input on 1000V AC range is 500V RMS (50 Hz to 10 kHz) decreasing to 100V RMS at 100 kHz.

Table 5.4 - Maximum AC Input on 1000 VAC Range

Maximum percentage of full scale AC RMS input on the 1000 V AC range is 500 V RMS from 50 Hz to 10 kHz decreasing to 100 V RMS at 100 kHz.

Frequency	Maximum AC Input Voltage
50 Hz to 10 kHz	500 V RMS
20 kHz	455 V RMS
30 kHz	415 V RMS
40 kHz	370 V RMS
50 kHz	325 V RMS
60 kHz	275 V RMS
70 kHz	230 V RMS
80 kHz	190 V RMS
90 kHz	145 V RMS
100 kHz	100 V RMS

(d) Adjust the DC voltage standard for an output of +1.000000.

(e) Null the thermal transfer voltmeter. Allow sufficient time for the thermocouple in the voltmeter to stabilize.

(f) Switch the thermal transfer voltmeter to AC input and apply a 1 volt RMS, 400 Hz sine wave signal from the AC laboratory source. Adjust the amplitude controls on the AC source to produce the same null on the thermal transfer voltmeter as with 1 volt DC.

(g) Slide the top cover of the instrument back far enough to expose the calibration controls on the top of the Signal Conditioning Module. (NOTE: If the instrument under calibration is a model 5370 it will be necessary to extend the Signal Conditioning Module forward, using extender kit no. (403017).

(h) Adjust the 1 volt low frequency potentiometer R-118 on the top of the Signal Conditioning Module to obtain a reading of 1.00000 ± 10 digit on the instruments readout.

(i) Repeat the same general procedure outlined in steps c through h above for each of the remaining calibration steps listed in table 5.2. Change the voltage and frequency, as indicated, for each range.

(j) The calibration of the AC converter is now complete. A check of the accuracy of the instrument at other frequencies and voltages than those listed in table 5.2. may be made by referring to table 5.3. This step is not necessary to the calibration of the AC converter, however certain user applications may require a more exact knowledge of the instruments accuracy at specific voltages and frequencies.

5.16 OHMS CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.1).

(NOTE: If the instrument is not equipped with the optional OHMS feature, the calibration is now concluded).

(a) Clip the input leads on the end of the instrument's input cable together.

(b) Set the DMM controls as follows:

Function: DC
Range: Auto
Ratio X10 Switch (on rear panel): Out (If applicable)

(c) The instrument should auto-range to the lowest range and read .000000.

(d) Adjust the ZERO OFFSET potentiometer on the front of the instrument so that the polarity indicators are "bouncing" between + and -.

(e) Select the OHMS function. The instrument should now indicate 0.00000 plus the resistance of the input cable. This resistance may give an offset of several digits. Carefully note the exact amount of this offset (if any).

(f) Connect the test leads to the 1000 ohm standard resistor.

(g) Adjust the 1 Kilohm Range Calibration Control (R154) so that the instrument indicates the exact value of the standard resistor plus the number of digits offset noted in step (c) above (the resistance of the input cable) within 2 digits.

(h) Connect the test leads to the 10 Megohm standard resistor.

(i) Adjust the 10,000 Kilohm Range Calibration Control (R134) so that the instrument indicates the exact value of the standard resistor within 25 digits.

(j) Connect test leads to the 10 Kilohm standard resistor.

(k) Adjust the 10 Kilohm Range Calibration control (R115) so that the instrument indicates the exact value of the standard resistor within 2 digits.

(l) Connect the test leads to the 100 Kilohm standard resistor.

(m) Adjust the 100 Kilohm Calibration Control (R123) so that the instrument indicates the exact value of the standard resistor within 2 digits.

(n) Connect the test leads to the 1 Megohm standard resistor.

(o) Adjust the 1000 Kilohm Calibration Control (R130) so that the instrument indicates the exact value of the standard resistor within 10 digits.

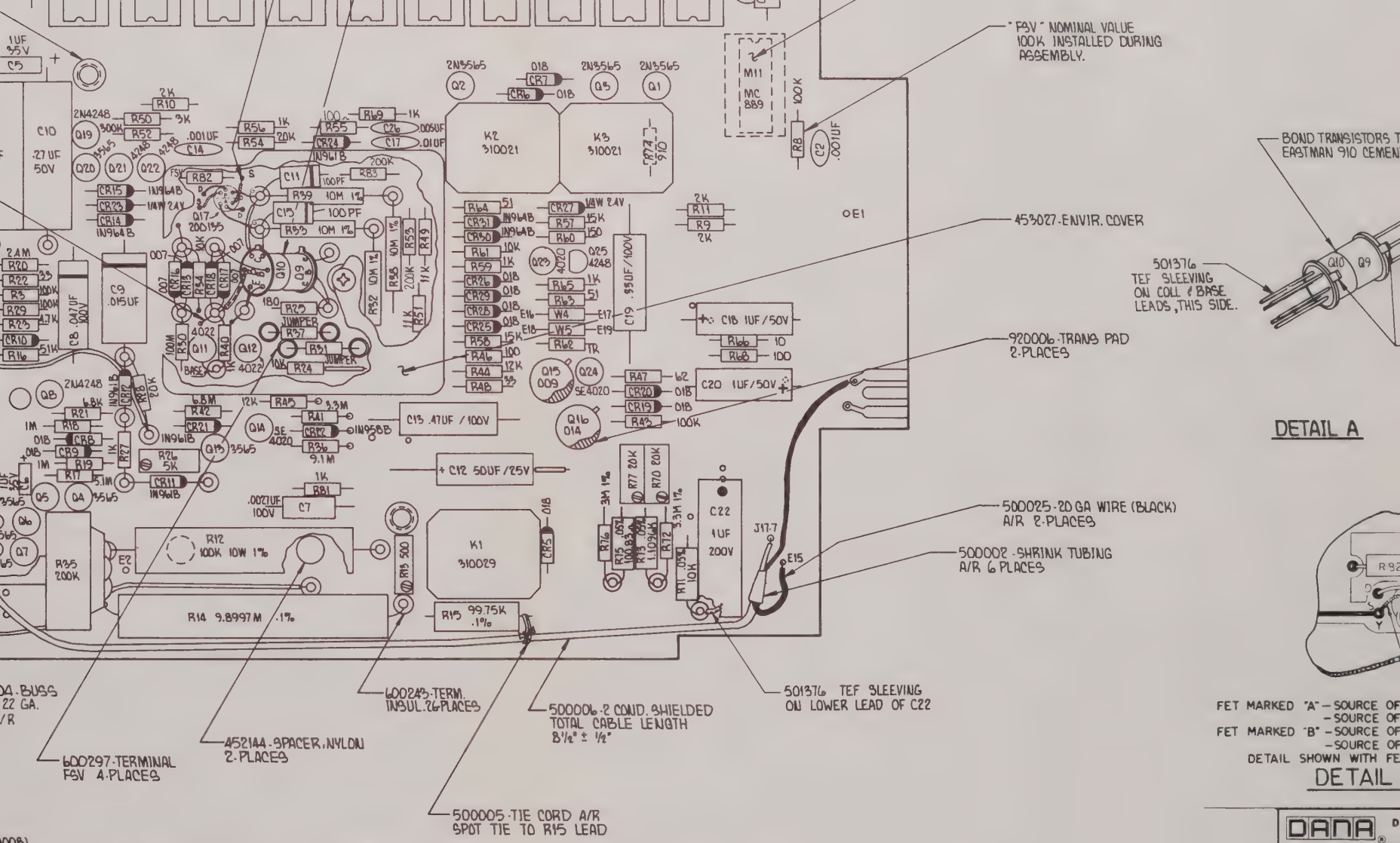
(p) Re-check steps (e) through (o) above and repeat any adjustments necessary until the instrument indicates correctly on each range without further adjustments.

SECTION 6

DRAWINGS

6.1 DRAWINGS.

Isolator Assembly, Module 600	403449
Isolator Schematic, Module 600	430961
AC Accessory, Model 50	403203
PCB Assembly, Model 50	403214
Schematic, Model 50	430870
Ohms Accessory, Model 60	403228
PCB Assembly, Model 60	403169
Schematic, Model 60	430871
AC/Ohms Accessory, Model 70	403229
PCB Assembly, Model 70	402581
Schematic, Model 70	430868


"FSV" NOMINAL VALUE 100K INSTALLED DURING ASSEMBLY.
453027-ENVIR. COVER
920006-TRANS PAD 2-PLACES
BOND TRANSISTORS T EASTMAN 910 CEMEN
501376 TEF SLEEVING ON COIL & BASE LEADS, THIS SIDE.
DETAIL A
500025-20 GA WIRE (BLACK) A/R 2-PLACES
500002-SHRINK TUBING A/R 6 PLACES
501376 TEF SLEEVING ON LOWER LEAD OF C22
600243-TERM. INSUL. 26 PLACES
500006-2 COND. SHIELDED TOTAL CABLE LENGTH 8 1/2" ± 1/2"
452144-SPACER, NYLON 2-PLACES
600297-TERMINAL FSV 4 PLACES
500005-TIE CORD A/R SPOT TIE TO R15 LEAD
K1 310029
K2 310021
K3 310021
R12 100K 10W 1%
R14 9.8997M .1%
R15 99.75K .1%
C22 1UF 200V
C19 .95UF/100V
C18 1UF/50V
C20 1UF/50V
C13 .47UF/100V
C12 50UF/25V

⚠2 CONNECTOR END OF CABLE IS TO BE COVERED WITH A 1¼" LG. PIECE OF 500002 SHRINK TUBING TO INSULATE CONNECTIONS AND EXPOSED PINS WHEN NONE OF THE CONVERTER ACCESSORIES ARE INSTALLED. SHRINK THE TUBING IN PLACE, LOOP THE CONV. END BACK AND SPOT TIE IT TO THE CABLE NEAR 93 TO SECURE IT.

⚠4 R82 "FSV" IN SERIES WITH SOURCE OF A OR B TO BE DETERMINED AT TIME OF ASSY. 200135 FET KIT SPECIFIES IF THE FSV RESISTOR IS FOR "A" OR "B" AND FURNISHES THE CORRECT VALUE RESISTOR. SEE DETAIL "B."

ADDITIONAL NOTES SEE SHEET 2.

FET MARKED "A" – SOURCE OF
– SOURCE OF
FET MARKED "B" – SOURCE OF
– SOURCE OF
DETAIL SHOWN WITH FE

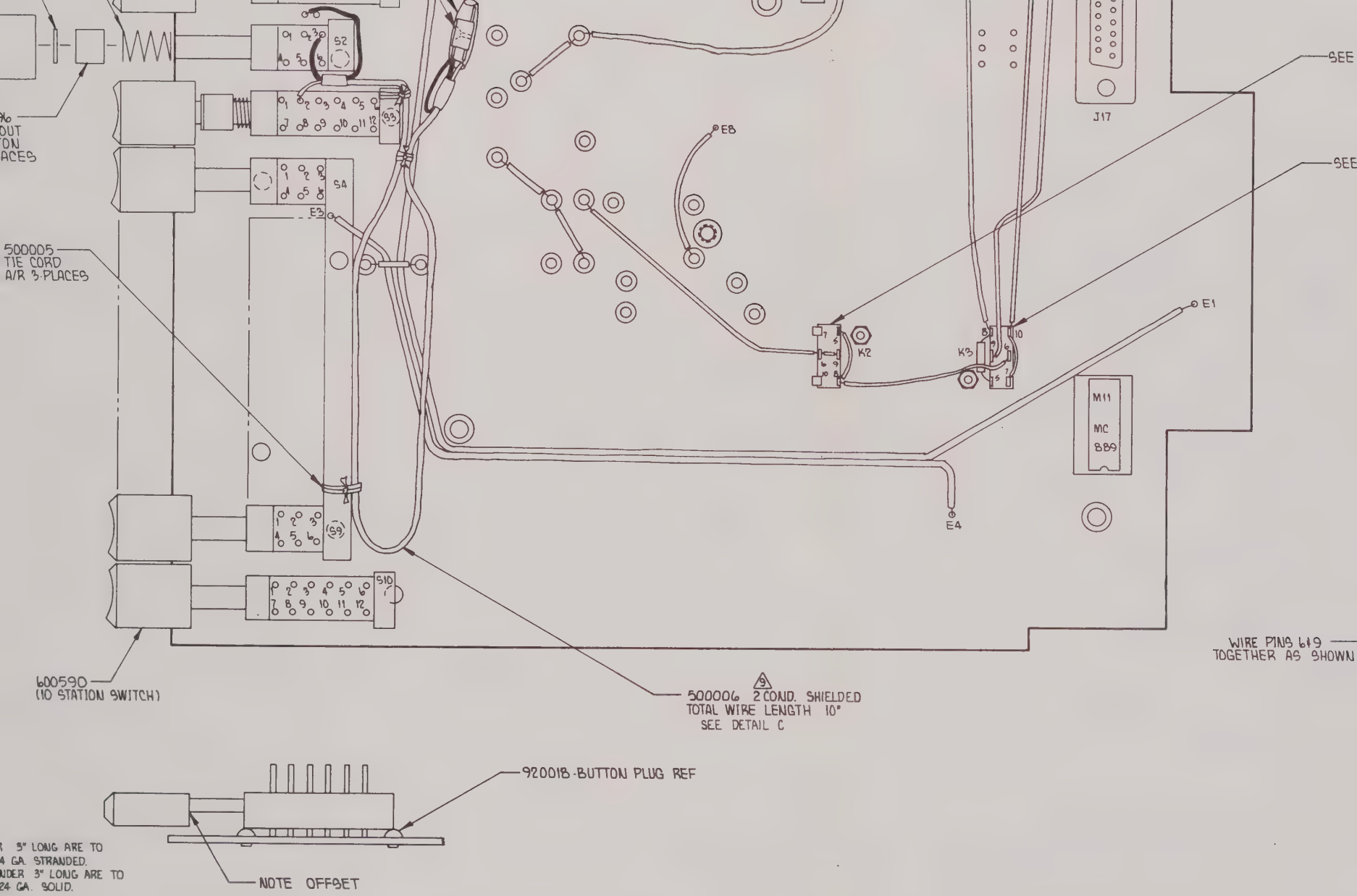
DETAIL

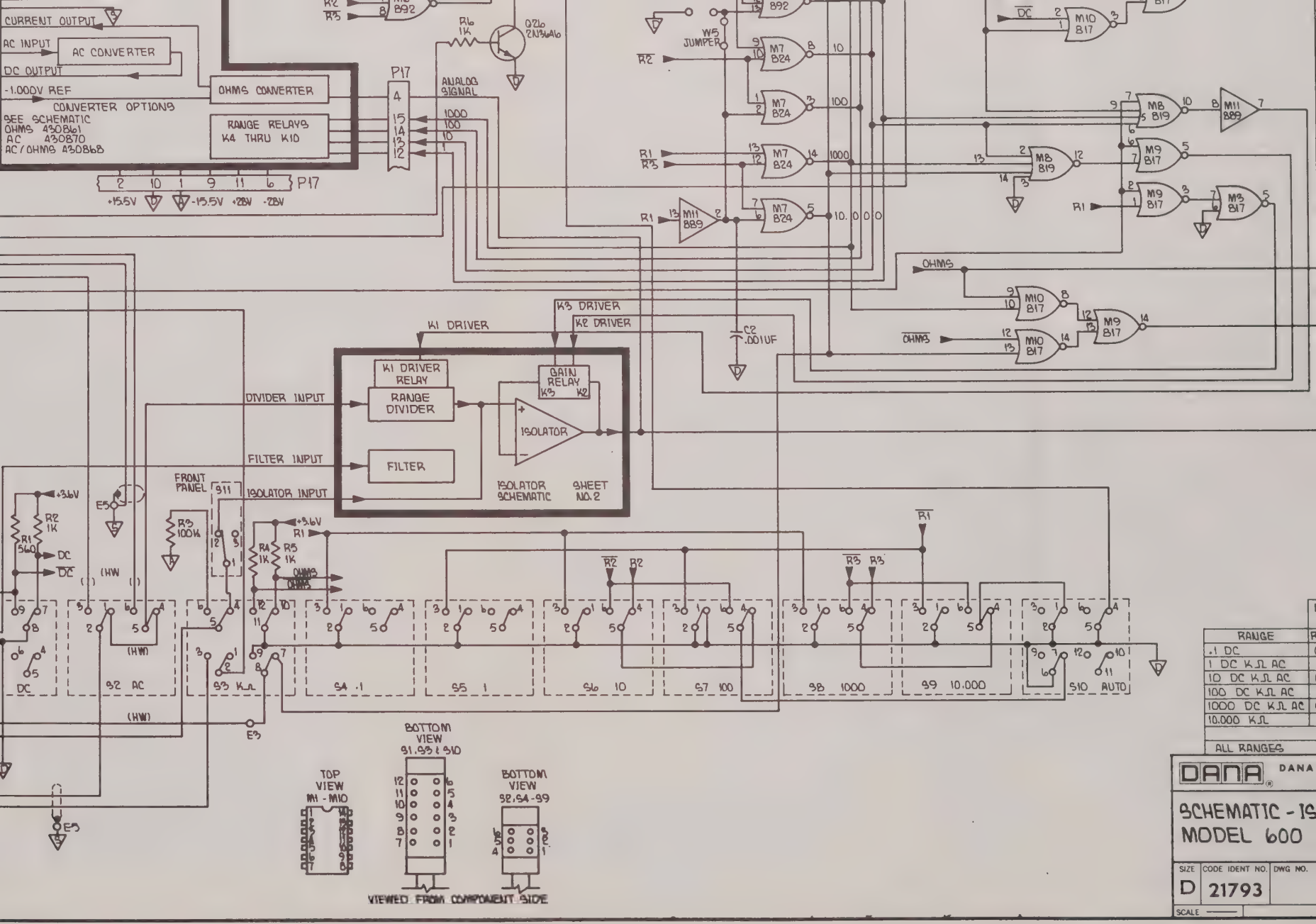
DANA

P.C. BOARD A
ISOLATOR M

SIZE	CODE IDENT NO.	DWG
D	21793	

SCALE 2/1


S2
S3
S4
S9
S10
E3
E8
E1
E4
K2
K3
J17
M11
MC
889
500005
TIE CORD
A/R 3 PLACES
600590
(10 STATION SWITCH)
500006 2 COND. SHIELDED
TOTAL WIRE LENGTH 10'
SEE DETAIL C
WIRE PINS 6 & 9
TOGETHER AS SHOWN
SEE
SEE
920018-BUTTON PLUG REF
NOTE OFFSET
3" LONG ARE TO
4 GA. STRANDED.
UNDER 3" LONG ARE TO
24 GA. SOLID.
FIED



RANGE
.1 DC
1 DC KΩ AC
10 DC KΩ AC
100 DC KΩ AC
1000 DC KΩ AC
10.000 KΩ
ALL RANGES

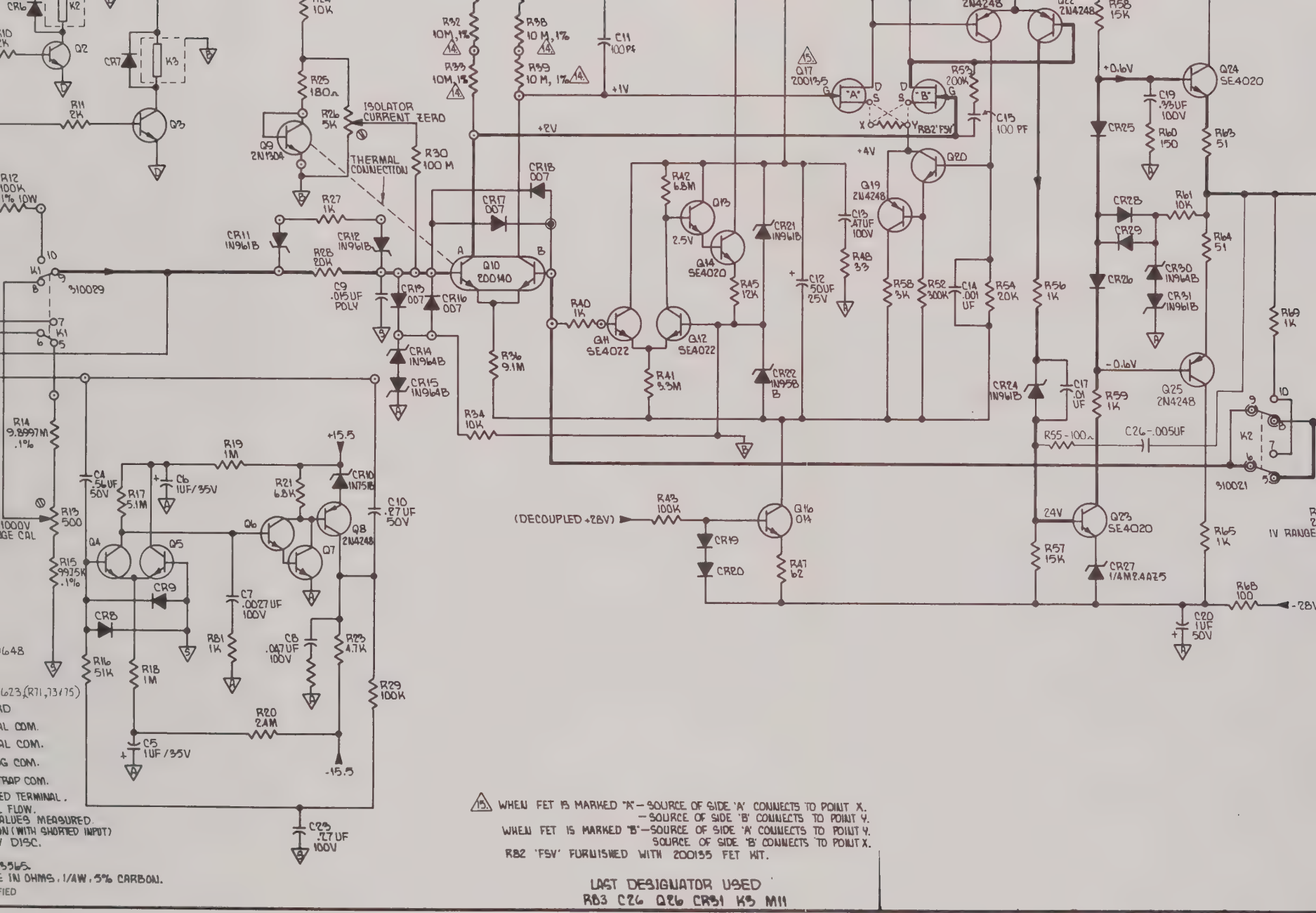
DANA

DANA

SCHEMATIC - 19
MODEL 600

SIZE	CODE IDENT NO.	DWG NO.
D	21793	

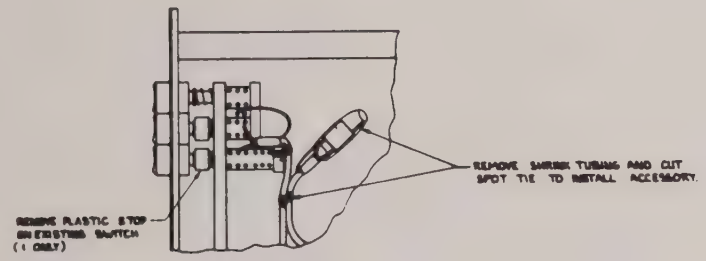
SCALE

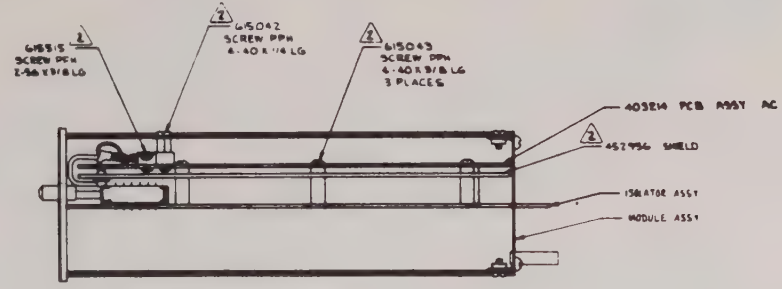


15. WHEN FET IS MARKED "A" — SOURCE OF SIDE 'A' CONNECTS TO POINT X.
— SOURCE OF SIDE 'B' CONNECTS TO POINT Y.
WHEN FET IS MARKED "B" — SOURCE OF SIDE 'A' CONNECTS TO POINT Y.
SOURCE OF SIDE 'B' CONNECTS TO POINT X.
R82 'FSV' FURNISHED WITH 200135 FET KIT.

LAST DESIGNATOR USED
R83 C26 Q26 CR31 K3 M11

REVISIONS				
LTR	DESCRIPTION	BY	CHK	APPD
	RELEASED PER DRN # 895			
B	SPOT TIE COAX TO SWITCH ED 2483			
C	DELETE P/N PER SOLATER AND ASSY MODULE PER E.O. 5886			
D	REVISE CABLE VIEW PER E.O. 6498			





SIDE EXTRUSION REMOVED FOR CLARITY

⚠ ALL ISOLATED HARDWARE TO BE ... FINISHED KIT (403217)

1 ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

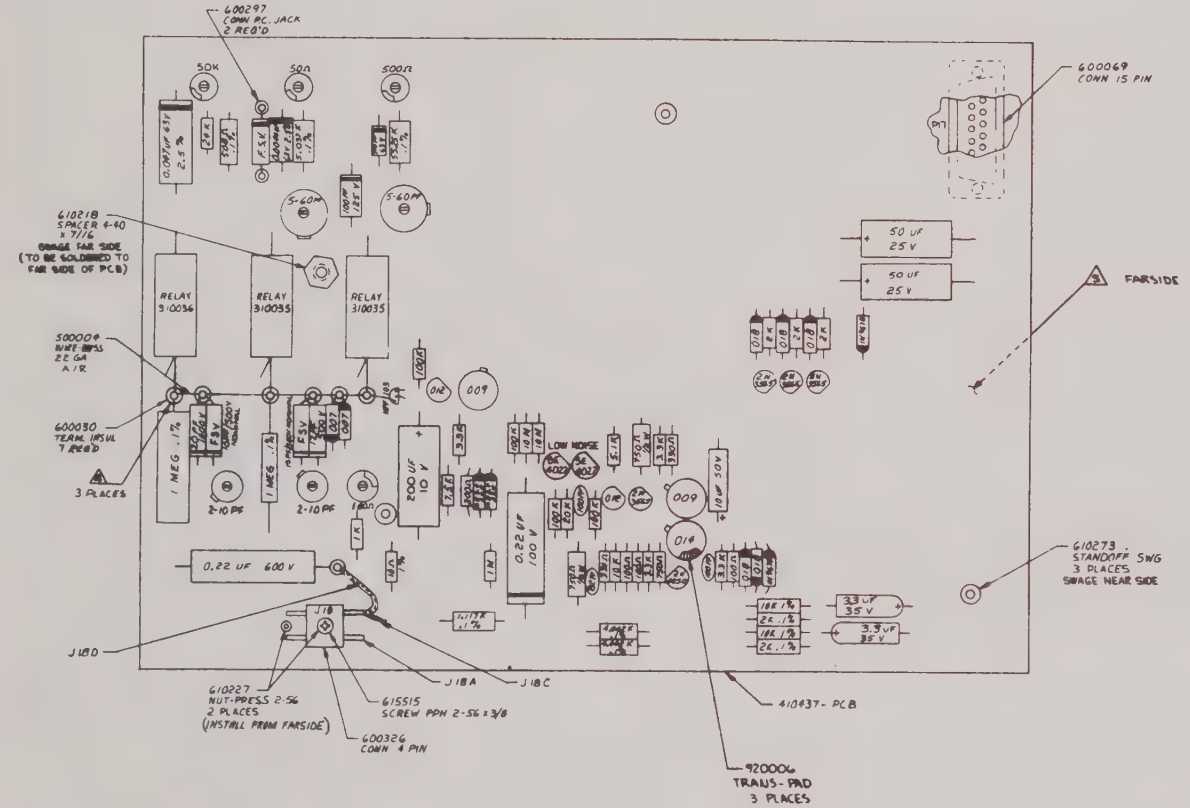
NOTE: UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY- A.C.
ACCESSORY

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403203	D

SCALE 1/1 SHEET 1 OF 2



▲ DO NOT WRAP RELAY LEADS AROUND TERMINALS

▲ ALL COMPONENT LEADS MUST BE CUT SO THAT NONE EXTEND BEYOND .062 (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE)

2 ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

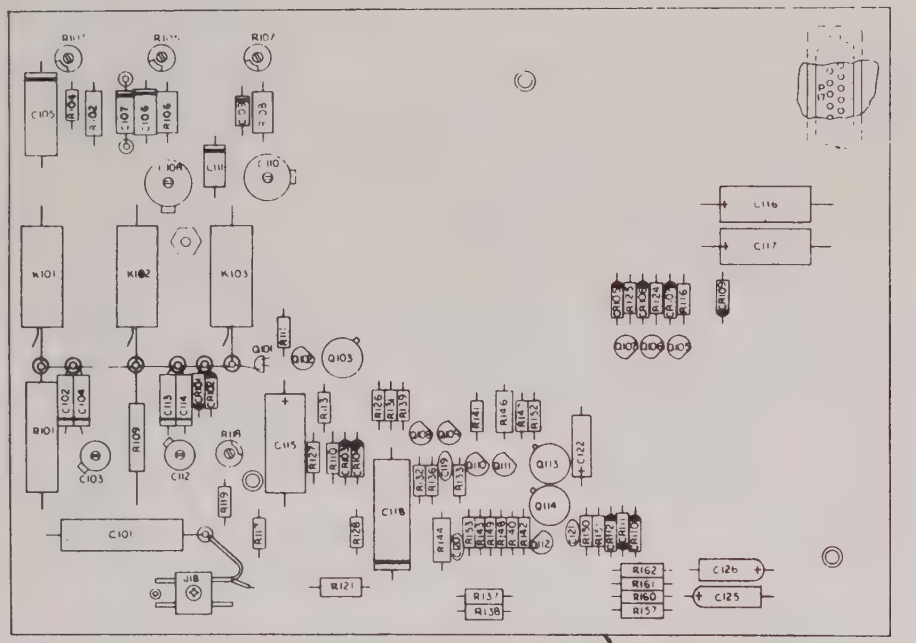
1. SCHEMATIC REFERENCE 430870.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C.B. ASSEMBLY
A.C. CONVERTER

SIZE	FSCM NO.	DWG NO.
D	21793	403214

SHT 1



NOTES UNLESS OTHERWISE SPECIFIED

1 REF SCHEMATIC NO. 430870

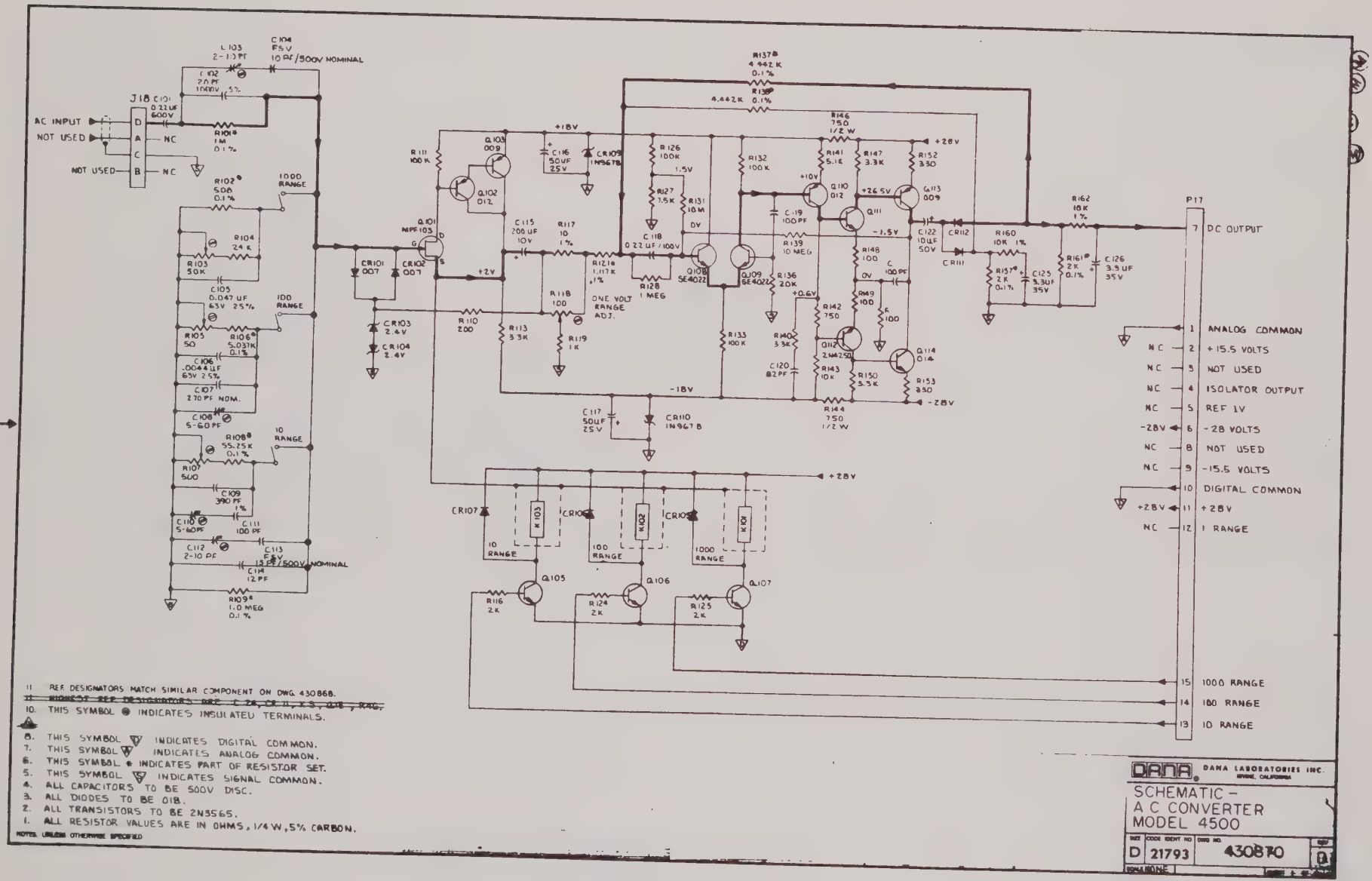
2 ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

DANA LABORATORIES INC.
IRVINE CALIFORNIA

P.C.B. ASSEMBLY
A.C. CONVERTER

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403214	F

SCALE | SHEET



11. REF. DESIGNATORS MATCH SIMILAR COMPONENT ON DWG. 430868.
~~12. HIGHEST REF. DESIGNATORS ARE: C 24, CR 11, K 3, R 18, RAG.~~
10. THIS SYMBOL ● INDICATES INSULATED TERMINALS.

9. THIS SYMBOL ▽ INDICATES DIGITAL COMMON.
7. THIS SYMBOL ▽ INDICATES ANALOG COMMON.
6. THIS SYMBOL * INDICATES PART OF RESISTOR SET.
5. THIS SYMBOL ▽ INDICATES SIGNAL COMMON.
4. ALL CAPACITORS TO BE 500V DISC.
3. ALL DIODES TO BE 018.
2. ALL TRANSISTORS TO BE 2N3565.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5% CARBON.

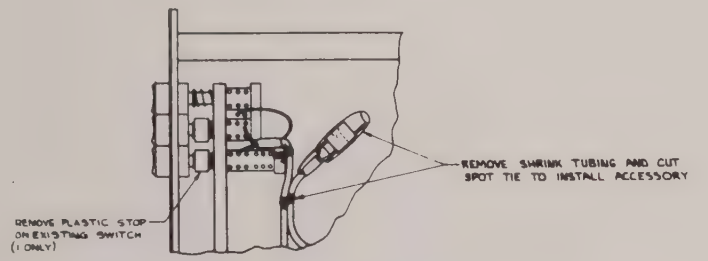
NOTES: UNLESS OTHERWISE SPECIFIED

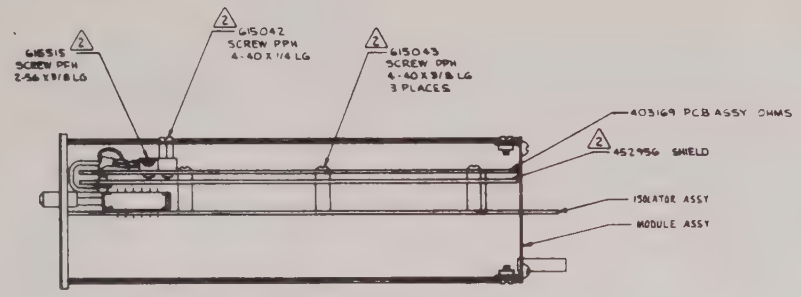
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC –
A C CONVERTER
MODEL 4500

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	430870	D

SCALE NONE





SIDE EXTRUSION REMOVED FOR CLARITY

⚠ ALL INDICATED HARDWARE IS INCLUDED IN FINISHING KIT (403227)

1 ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

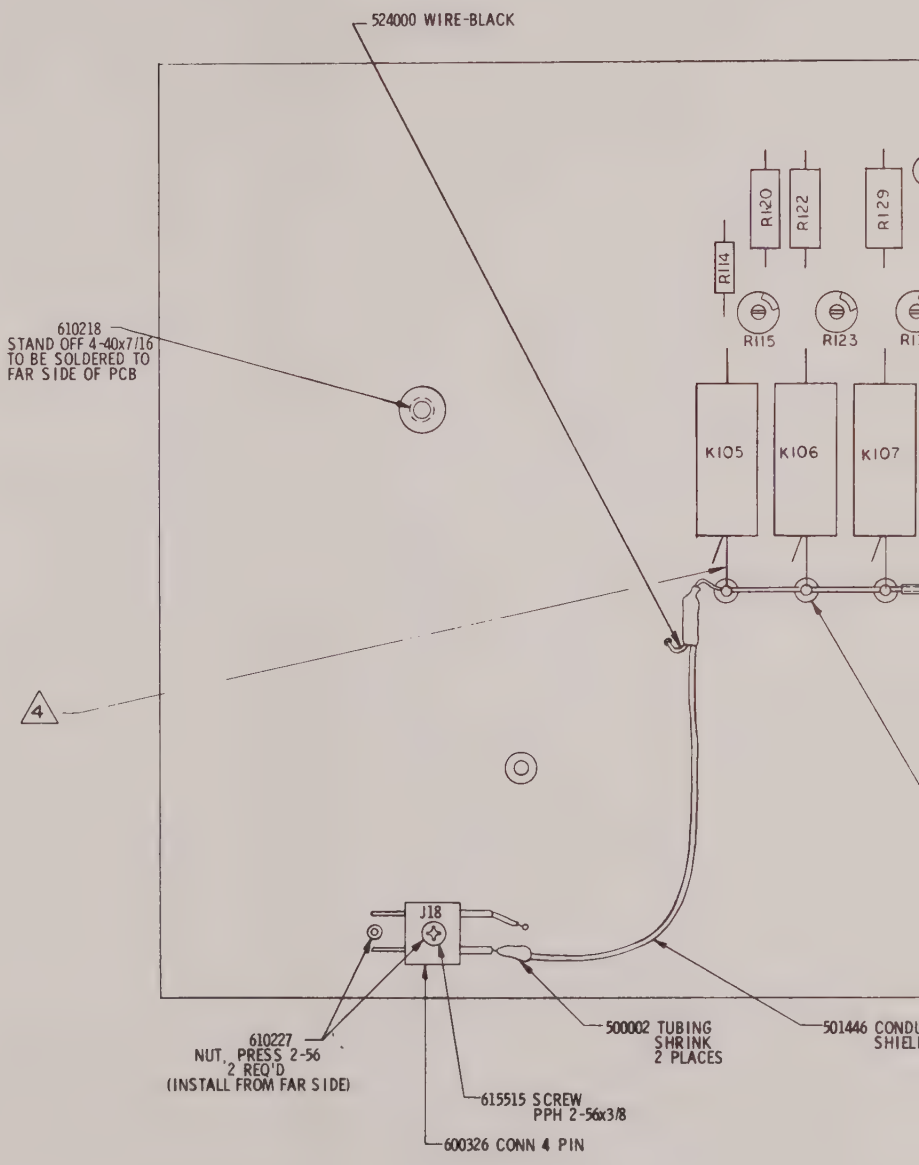
DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

ASSY- OHMS ACCESSORY

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403228	D

SCALE 1/1 SHEET 1 OF 2

SHT 2 IS AN A



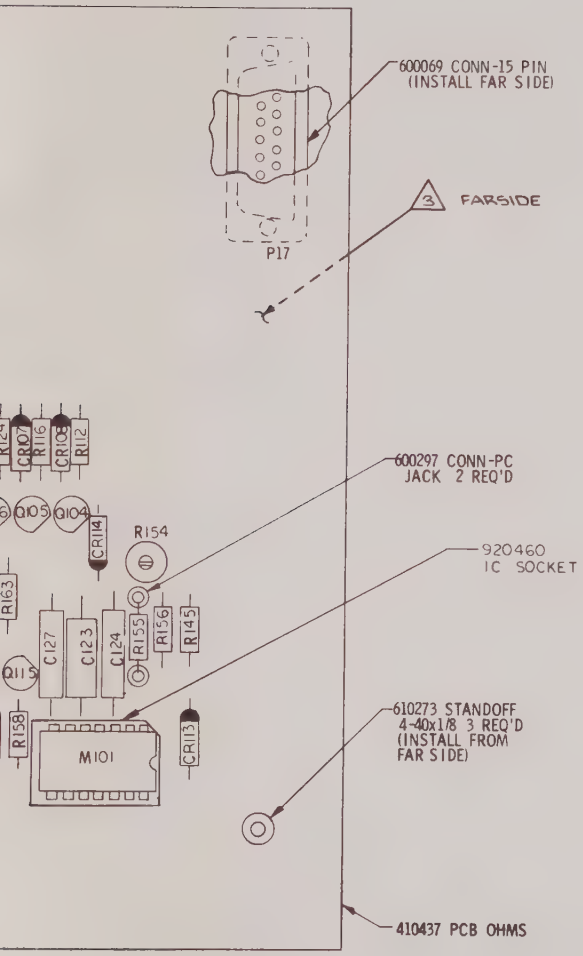
4. DO NOT BEND OR PULL RELAY LEADS, SOLDER DIRECTLY TO TERMINALS.

3. LEADS TO BE CUT SO THAT NONE EXTEND BEYOND .062, (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE)

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

1. SCHEMATIC REFERENCE 430871

NOTES: UNLESS OTHERWISE SPECIFIED



8030 TERM INSULATED
5 REQ'D

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C123	121088	CAP 0.01 UF/100V	1
C124	121146	CAP 0.0047 UF/100V	2
C127	121146	CAP 0.0047 UF/100V	REF
	501376	SLEEVING	A/R
	500043	WIRE TEF COATED BUSS	A/R
CR108	211083	DIODE 018	4
CR107	211083	DIODE 018	REF
CR106	211083	DIODE 018	REF
CR105	211083	DIODE 018	REF
CR113	221177	1/4 M 2.4 AZ5	3
CR114	221177	1/4 M 2.4 AZ5	REF
CR115	221177	1/4 M 2.4 AZ5	REF
K104	310036	RELAY	4
K105	310036	RELAY	REF
K106	310036	RELAY	REF
K107	310036	RELAY	REF
M101	230026	IC MC709C	1
Q115	200043	TSTR 2N3565	5
Q104	200043	TSTR 2N3565	REF
↕	↕	↕	↕
Q107	200043	TSTR 2N3565	REF
R112	000202	RES 2K	4
R114	001737	RES FSV (680K NOM)	2
R115	040159	POT 500K	1
R116	000202	RES 2K	REF
R120	020494	RES 8.19K 0.1%	1
R122	020495	RES 89.815K 0.1%	1
R123	040115	POT 500 OHM	1

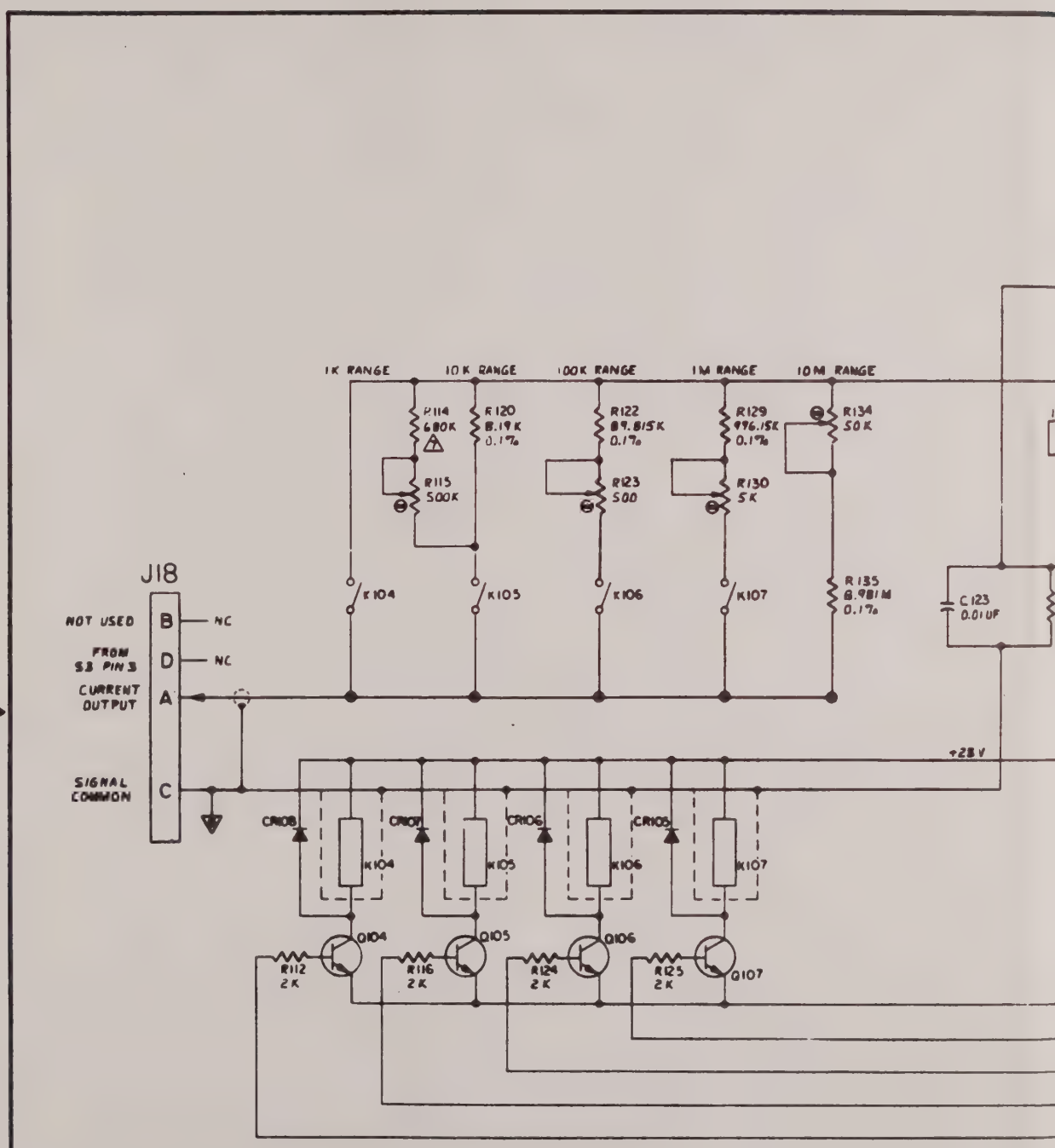
REF DES OR ITEM	P/N	DESCRIPTION	QTY
R124	000202	RES 2K	REF
R129	020496	RES 996.15K 0.1%	1
R130	040097	POT 5K	1
R125	000202	RES 2K	REF
R134	040104	POT 50K	1
R135	010357	RES 8.981M 0.1%	1
R145	000685	RES 6.8M	1
R154	040088	POT 100K 10%	1
R155	001737	RES FSV (5.1M NOM)	REF
R156	000152	RES 1.5K	1
R159	000821	RES 820 OHM	1
R158	000512	RES 5.1K	1
R163	000912	RES 9.1K	1
R164	020050	RES 9K 0.01%	1
R165	021395	RES 1K 0.01%	1
	920460	I.C. SOCKET	1
	410437	PCB AC & OHMS	1
	430871	SCHEMATIC	REF
	500002	TUBING SHRINK	A/R
	500004	WIRE-BUSS 22 GA	A/R
	501446	CONDUCTOR SHIELDED	A/R
	524000	WIRE-BLACK	A/R
	600030	TERM ISOLATED	5
	600069	CONN-15 PIN	1
	600297	CONN-PC JACK	2
	600326	CONN 4 PIN	1
	610218	STANDOFF, 4-40x7/16	1
	610227	NUT-PRESS 2-56	2
	610273	STANDOFF, 4-40x1/8	3
	615515	SCREW, PFH 2-56x3/8	1
	920026	SOLDER WIRE	A/R

DANA DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSEMBLY
OHMS CONVERTER

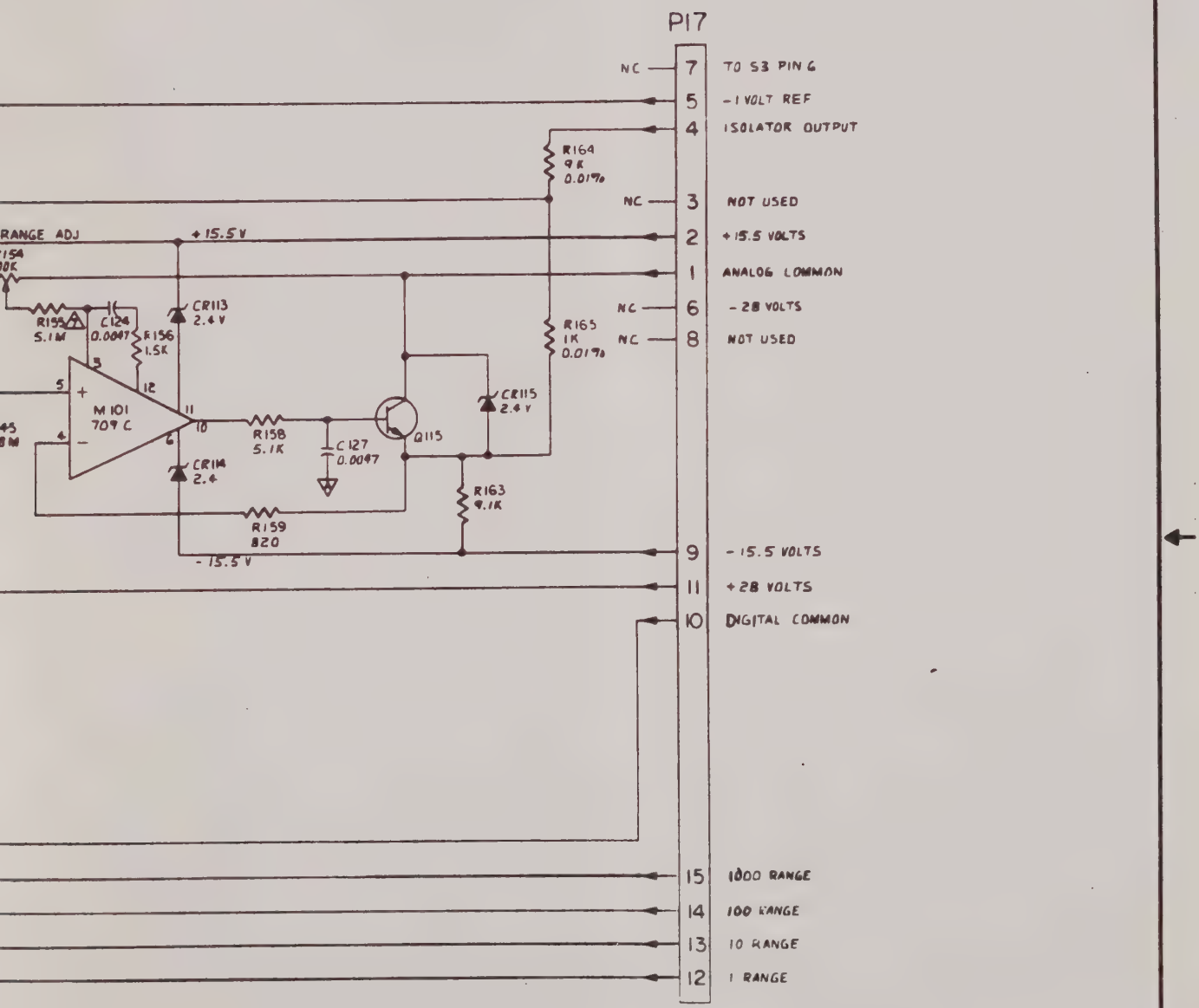
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403169	F

SCALE 2 - 1 SHEET 1 OF 2



8. H.F. DESIGNATORS MATCH SIMILAR COMPONENT ON DWG. 430868.
~~9. HIGHEST REF DESIGNATORS USED: C8, CR9, K8, R81, Q8, P&S.~~
⚠ FACTORY SELECT, NOMINAL VALUES SHOWN.
6. THIS SYMBOL ⓖ INDICATES INSULATED TERMINAL.
5. ALL VOLTAGES ARE APPROXIMATE VALUES MEASURED WITH RESPECT TO ANALOG COMMON.
4. THIS SYMBOL ▽ INDICATES SIGNAL COMMON.
3. ALL DIODES TO BE: D1B.
2. ALL TRANSISTORS TO BE: 2N3565.
1. ALL RESISTOR VALUES ARE IN OHMS, ¼W, 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

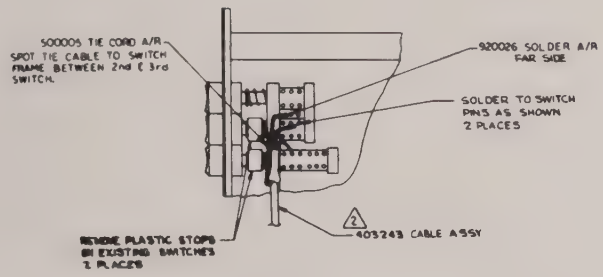


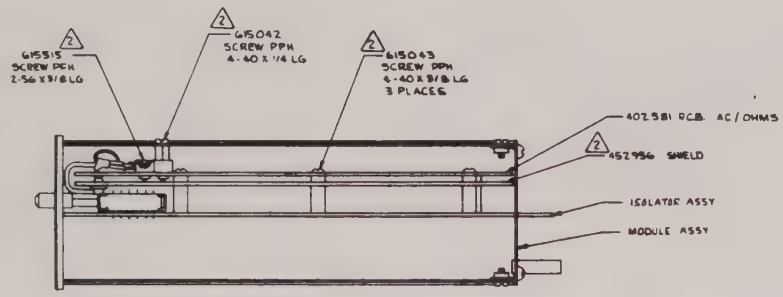
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC -
OHMS CONVERTER
MODEL 350

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430871	B

SCALE — SHEET 1 OF 1


500005 TIE CORD A/R
SPOT TIE CABLE TO SWITCH FRAME BETWEEN 2nd & 3rd SWITCH.
920026 SOLDER A/R FAR SIDE
SOLDER TO SWITCH PINS AS SHOWN 2 PLACES
403243 CABLE ASSY
REMOVE PLASTIC STOPS ON EXISTING SWITCHES 2 PLACES


615515 SCREW PPH 2-56 X 3/8 LG
615042 SCREW PPH 4-40 X 1/4 LG
615043 SCREW PPH 4-40 X 3/8 LG 3 PLACES
402581 PCB. AC/OHMS
452986 SHIELD
ISOLATOR ASSY
MODULE ASSY

SIDE EXTRUSION REMOVED FOR CLARITY

△ ALL INDICATED HARDWARE IS INCLUDED IN FINISHING KIT (403227)
1 ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

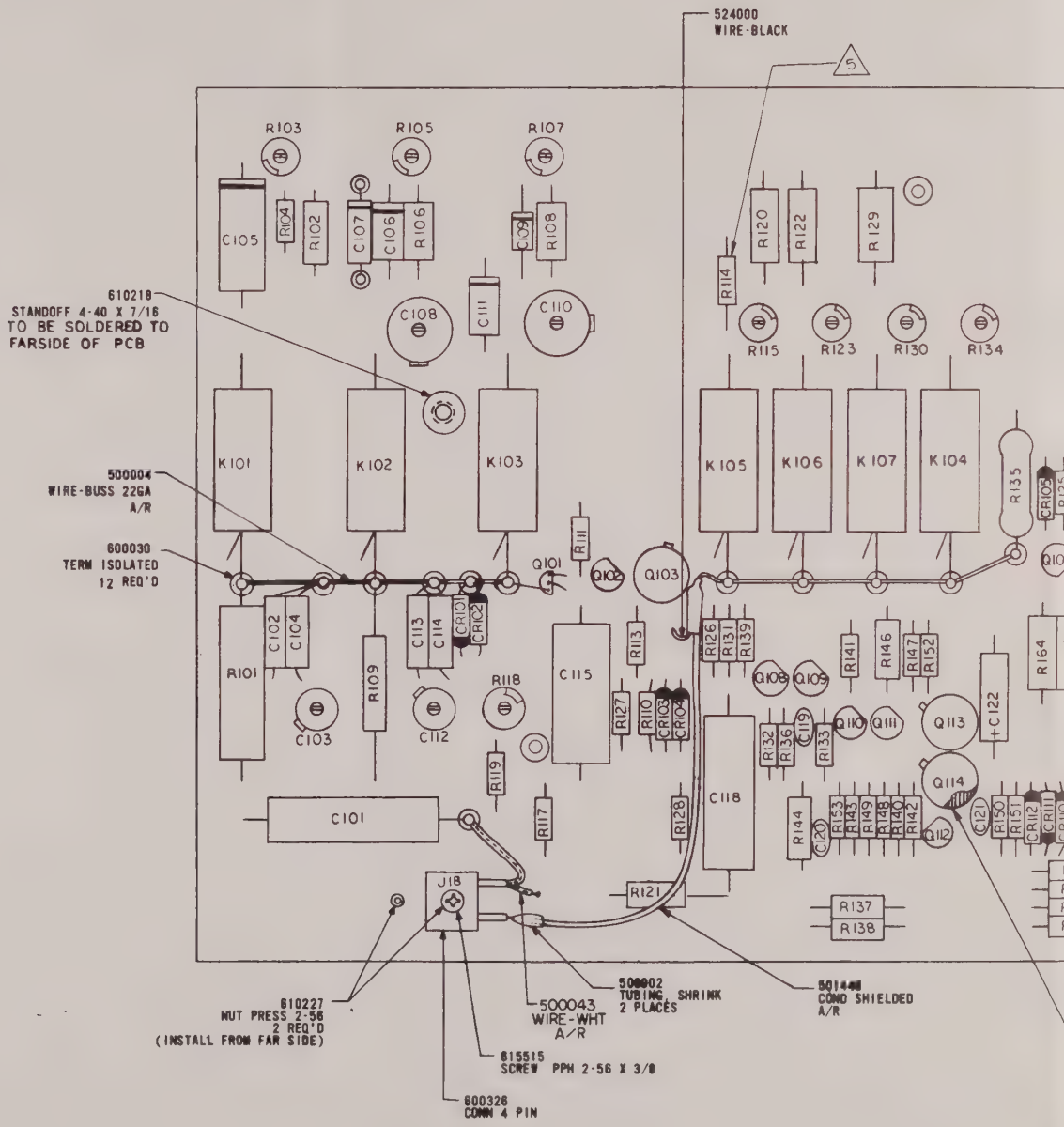
NOTES: UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY- AC/OHMS
ACCESSORY

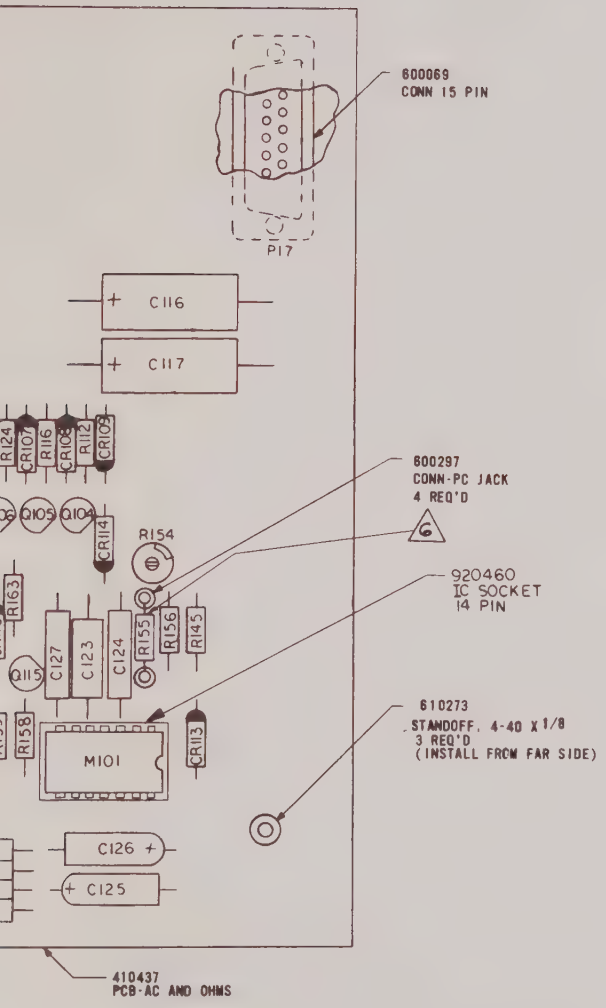
SIZE	FSCM NO.	DWG NO.	REV
D	21793	403229	C

SHT 2 IS ON "A" SIZE



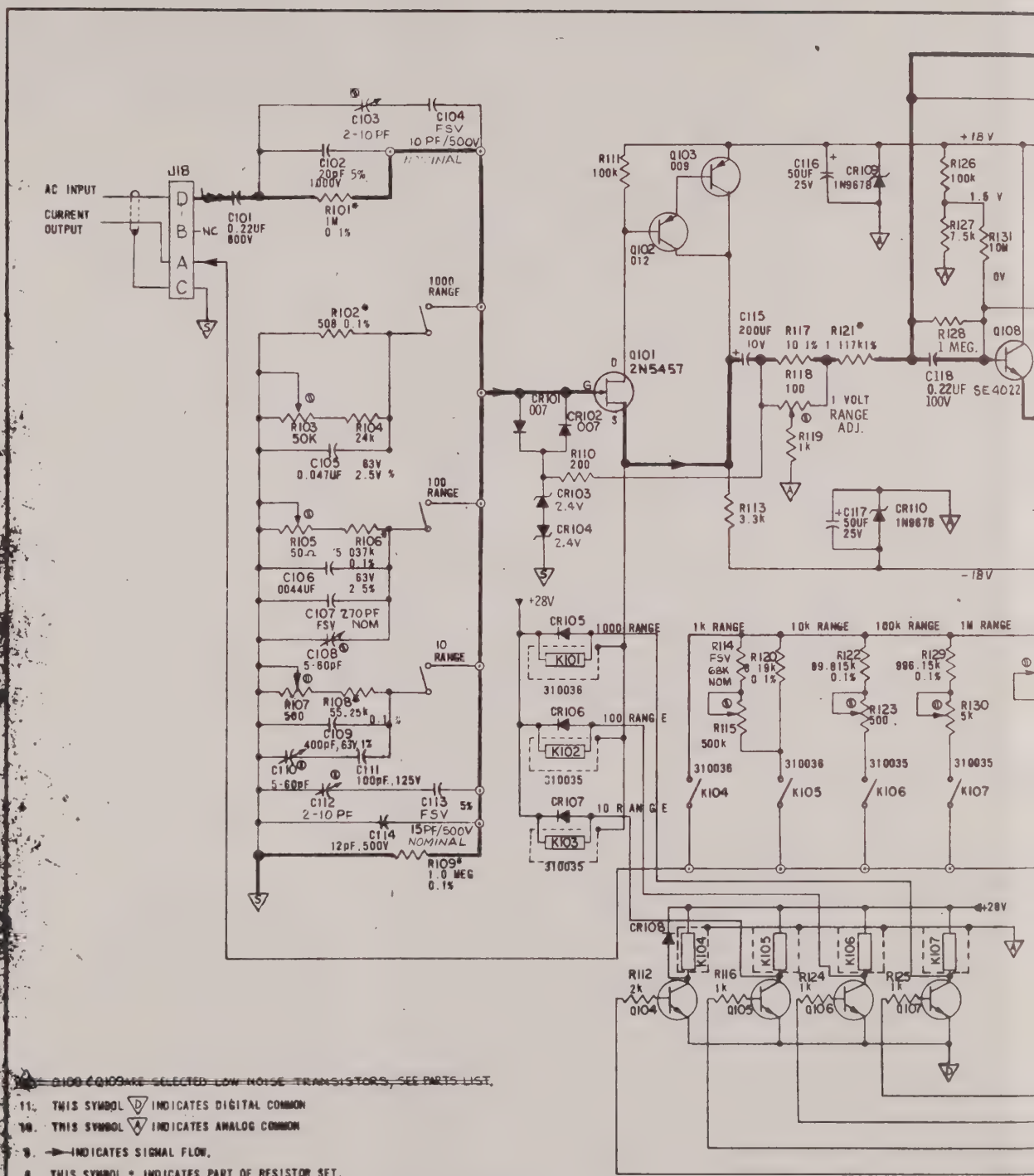
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO BANK QUARTERMASTER STANDARDS.
1. SCHEMATIC REFERENCE 420828

NOTES: UNLESS OTHERWISE SPECIFIED



-920006
TRANS-PAD
3 PLCS.

DANA LABORATORIES INC. IRVINE, CALIFORNIA			
ASSY A.C. & OHMS CONVERTER			
SIZE D	CODE IDENT NO. 21793	DWG NO. 402581	
SCALE 2:1		SHEET 1	



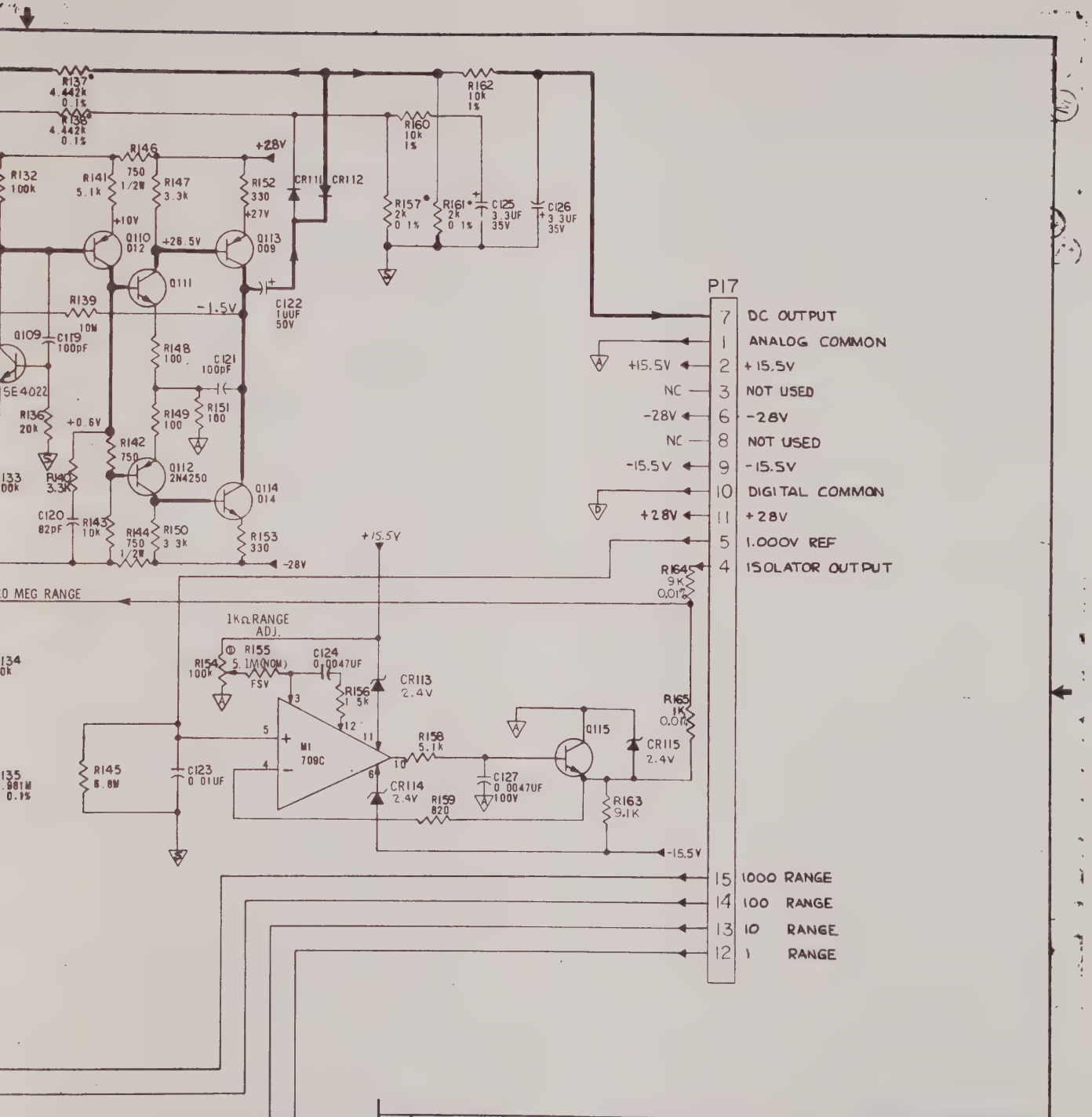
~~Q100 Q101 ARE SELECTED LOW NOISE TRANSISTORS, SEE PARTS LIST.~~

11. THIS SYMBOL (D) INDICATES DIGITAL COMMON
10. THIS SYMBOL (A) INDICATES ANALOG COMMON
9. → INDICATES SIGNAL FLOW.
8. THIS SYMBOL * INDICATES PART OF RESISTOR SET.
7. THIS SYMBOL ⊙ INDICATES INSULATED TERMINAL
6. ALL VOLTAGES ARE APPROXIMATE VALUES MEASURED WITH RESPECT TO ANALOG COMMON.
5. ALL CAPACITORS TO BE 500V DISC.
4. THIS SYMBOL (S) INDICATES SIGNAL COMMON.
3. ALL DIODES TO BE: 018
2. ALL TRANSISTORS TO BE 2N3565
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W. 5%. CARBON

NOTE: UNLESS OTHERWISE SPECIFIED

LAST DESIGNATORS USED

C127	CR115	M101	K107	Q115	R165



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC
AC AND OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430868	D

SCALE | WT | SHEET 4 OF

PARTS LIST

ASSEMBLY 403449 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION							
CR05	211083	DIODE	SILICO		018			DANA	211083
CR06	211083	DIODE	SILICO		018			DANA	211083
CR07	211083	DIODE	SILICO		018			DANA	211083
CR08	211083	DIODE	SILICO		018			DANA	211083
CR09	211083	DIODE	SILICO		018			DANA	211083
CR10	220007	DIODE	SILICO	ZENER	1N751			MOTOROLA	1N751
CR11	220004	DIODE	SILICO	ZENER	1N961B			MOTOROLA	1N961B
CR12	220004	DIODE	SILICO	ZENER	1N961B			MOTOROLA	1N961B
CR13	211236	DIODE	SILICO		007			DANA	211236
CR14	220016	DIODE	SILICO	ZENER	1N964B			MOTOROLA	1N964B
CR15	220016	DIODE	SILICO	ZENER	1N964B			MOTOROLA	1N964B
CR16	211236	DIODE	SILICO		007			DANA	211236
CR17	211236	DIODE	SILICO		007			DANA	211236
CR18	211236	DIODE	SILICO		007			DANA	211236
CR19	211083	DIODE	SILICO		018			DANA	211083
CR20	211083	DIODE	SILICO		018			DANA	211083
CR21	220004	DIODE	SILICO	ZENER	1N961B			MOTOROLA	1N961B
CR22	220012	DIODE	SILICO	ZENER	1N958B			MOTOROLA	1N958B
CR23	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR24	220004	DIODE	SILICO	ZENER	1N961B			MOTOROLA	1N961B
CR25	211083	DIODE	SILICO		018			DANA	211083
CR26	211083	DIODE	SILICO		018			DANA	211083
CR27	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR28	211083	DIODE	SILICO		018			DANA	211083
CR29	211083	DIODE	SILICO		018			DANA	211083
CR30	220016	DIODE	SILICO	ZENER	1N964B			MOTOROLA	1N964B
CR31	220016	DIODE	SILICO	ZENER	1N964B			MOTOROLA	1N964B
C01	110086	CAP	TANTA	47	MFD	10 V	10%	KEMET	K47C6K
C02	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C03	100017	CAP	CERAM	.01	MFD	200 V	10%	SPRAGUE	TH-S10
C04	120117	CAP	POLY	.056		10 V		ELPAC	DD1K563J
C05	110071	CAP	ELECT	.1	MFD	35 V	10%	KEMET	K1W35K
C06	110071	CAP	ELECT	.1	MFD	35 V	10%	KEMET	K1W35K
C07	120175	CAP	MYLAR	.0027	MFD	100 V	10%	IMB	ZA1296K
C08	121093	CAP	MYLAR	.047	MFD	100 V	10%	CDE	WMF1S47
C09	120135	CAP	POLYS	.015	MFD	33 V	10%	MIAL	611.3S

PARTS LIST

ASSEMBLY 403449 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION						
C10	120178	CAP	MYLAR	.27 MFD	50 V	5%	IMB	PV2A274J
C11	120153	CAP	POLYS	47 PFD	125 V	10%	MIAL	611
C12	110047	CAP	ELECT	50 MFD	50 V	20%	DUCATI	50-50
C13	120026	CAP	MYLAR	.47 MFD	100 V	10%	IMB	AS2B474K
C14	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C15	120176	CAP	POLY	150 PFD	63 V	20%	MIAL	611.1
C16	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C17	100017	CAP	CERAM	.01 MFD	200 V	10%	SPRAGUE	TH-S10
C18	110040	CAP	ELECT	1 MFD	50 V	20%	DUCATI	1-50
C19	120185	CAP	MYLAR	.33 MFD	100 V	10%	CD	WMF1P33
C20	110040	CAP	ELECT	1 MFD	50 V	20%	DUCATI	1-50
C21	120134	CAP	MYLAR	1 MFD	200 V	10%	PAKTRON	MF1200LL
C22	120134	CAP	MYLAR	1 MFD	200 V	10%	PAKTRON	MF1200LL
C23	120110	CAP	MYLAR	.27 MFD	100 V	10%	CD	WMF1P27
C24	100017	CAP	CERAM	.01 MFD	200 V	10%	SPRAGUE	TH-S10
J17	600063	CONN	15 S				CINCH	DA15S2
K01	310029	RELAY					AM ZETTLR	AZ420-56
K02	310021	RELAY	DC	2 PDT	24V		ALLIED	AZ42056105
K03	310021	RELAY	DC	2 PDT	24V		ALLIED	AZ42056105
M01	230019	INTEGRATED CIRCUIT		MC824P			MOTOROLA	MC824P
M02	230023	INTEGRATED CIRCUIT		MC890P			MOTOROLA	MC890P
M03	230018	INTEGRATED CIRCUIT		MC817P			MOTOROLA	MC817P
M04	230055	INTEGRATED CIRCUIT		MC819P			MOTOROLA	MC819P
M05	230015	INTEGRATED CIRCUIT		MC723P			MOTOROLA	MC723P
M06	230053	INTEGRATED CIRCUIT		MC892P			MOTOROLA	MC892P
M07	230019	INTEGRATED CIRCUIT		MC824P			MOTOROLA	MC824P
M08	230055	INTEGRATED CIRCUIT		MC819P			MOTOROLA	MC819P
M09	230018	INTEGRATED CIRCUIT		MC817P			MOTOROLA	MC817P
M10	230018	INTEGRATED CIRCUIT		MC817P			MOTOROLA	MC817P
M11	230022	INTEGRATED CIRCUIT		MC889P			MOTOROLA	MC889P
Q01	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q02	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q03	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q04	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q05	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565

PARTS LIST

ASSEMBLY 403449 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION						
Q06	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q07	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q08	200022	TRANS SILICO PNP	012				DANA	200022
Q09	201084	TRANS GERMAN PNP	2N1304				TI	2N1304
Q10	200140	TRANS DUAL	TYPE 140 NPN				DANA	200140
Q11	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q14	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q15	200052	TRANS SILICO PNP	009				DANA	200052
Q16	200035	TRANS SILICO NPN	014				DANA	200035
Q17	200135	FET KIT					DANA	200135
Q19	200022	TRANS SILICO PNP	012				DANA	200022
Q20	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q21	200022	TRANS SILICO PNP	012				DANA	200022
Q22	200022	TRANS SILICO PNP	012				DANA	200022
Q23	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q24	200043	TRANS SILICO NPN	2N3565				FAIRCHILD	2N3565
Q25	200022	TRANS SILICO PNP	012				DANA	200022
Q26	200037	TRANS SILICO NPN	2N3646				FAIRCHILD	2N3646
R01	000102	RES CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R02	000102	RES CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R03	000104	RES CARBON	100 K	5%	1/4 W		OHMITE	RC07GF104J
R04	000102	RES CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R05	000102	RES CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R06	000102	RES CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R07	000511	RES CARBON	510 OHM	5%	1/4 W		OHMITE	RC07GF511J
R08	000104	RES CARBON	100 K	5%	1/4 W		OHMITE	RC07GF104J
R09	000202	RES CARBON	2 K	5%	1/4 W		OHMITE	RC07GF202J
R10	000202	RES CARBON	2 K	5%	1/4 W		OHMITE	RC07GF202J
R11	000202	RES CARBON	2 K	5%	1/4 W		OHMITE	RC07GF202J
R12	030015	RES WW	100 K	1%	10 W	C-F	M-100	
R13	040093	RES VARI	500 OHM			SPECTRO	50-3-1-501	
R14	010334	RES	SET			DANA	010334	
R15	010334	RES	SET			DANA	010334	

PARTS LIST

ASSEMBLY 403449 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION							
R16	000513	RES	CARBON	51	K	5%	1/4 W	OHMITE	RC07GF513J
R17	000515	RES	CARBON	5.1	M	5%	1/4 W	OHMITE	RC07GF515J
R18	000105	RES	CARBON	1	M	5%	1/4 W	OHMITE	RC07GF105J
R19	000105	RES	CARBON	1	M	5%	1/4 W	OHMITE	RC07GF105J
R20	000245	RES	CARBON	2.4	M	5%	1/4 W	OHMITE	RC07GF245J
R21	000682	RES	CARBON	6.8	K	5%	1/4 W	OHMITE	RC07GF682J
R22	000330	RES	CARBON	33	K	5%	1/4 W	OHMITE	RC07GF330J
R23	000472	RES	CARBON	4.7	K	5%	1/4 W	OHMITE	RC07GF472J
R24	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R25	000750	RES	CARBON	75	OHM	5%	1/4 W	OHMITE	RC07GF750J
R26	040109	RES	VARI	5	K			SPECTROL	50-3
R27	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R28	000203	RES	CARBON	20	K	5%	1/4 W	OHMITE	RC07GF203J
R29	000104	RES	CARBON	100	K	5%	1/4 W	OHMITE	RC07GF104J
R30	000516	RES	CARBON	51	M	5%	1/4 W	OHMITE	RC07GF516J
R31	600245	JUMPER						GETTIG	L-2007-1
R32	010648	RES	METAL SET	10	MEG		.1% T2	PME	70C
R33	010648	RES	METAL SET	10	MEG		.1% T2	PME	70C
R34	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R35	040134	RES	VARI	200	K			CTS	134
R36	000915	RES	CARBON	910	K	5%	1/4 W	OHMITE	RC07GF915J
R37	600245	JUMPER						GETTIG	L-2007-1
R38	010648	RES	METAL SET	10	MEG		.1% T2	PME	70C
R39	010648	RES	METAL SET	10	MEG		.1% T2	PME	70C
R40	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R41	000335	RES	CARBON	3.3	M	5%	1/4 W	OHMITE	RC07GF335J
R42	000685	RES	CARBON	6.8	MEG	5%	1/4 W	OHMITE	RC07GF685J
R43	000104	RES	CARBON	100	K	5%	1/4 W	OHMITE	RC07GF104J
R44	000123	RES	CARBON	12	K	5%	1/4 W	OHMITE	RC07GF123J
R45	000123	RES	CARBON	12	K	5%	1/4 W	OHMITE	RC07GF123J
R46	000101	RES	CARBON	100	OHM	5%	1/4 W	OHMITE	RC07GF101J
R47	000620	RES	CARBON	62	OHM	5%	1/4 W	OHMITE	RC07GF620J
R48	000330	RES	CARBON	33	K	5%	1/4 W	OHMITE	RC07GF330J
R49	000113	RES	CARBON	11	K	5%	1/4 W	OHMITE	RC07GF113J
R50	000302	RES	CARBON	3	K	5%	1/4 W	OHMITE	RC07GF302J

ASSEMBLY 403449 - Model 600

REF. DESIG.	PART NO.	DESCRIPTION							
R51	000113	RES	CARBON	11	K	5%	1/4 W	OHMITE	RC07GF113J
R52	000304	RES	CARBON	300	K	5%	1/4 W	OHMITE	RC07GF304J
R53	000513	RES	CARBON	51	K	5%	1/4 W	OHMITE	RC07GF513J
R54	000203	RES	CARBON	20	K	5%	1/4 W	OHMITE	RC07GF203J
R55	000510	RES	CARBON	51	OHM	5%	1/4 W	OHMITE	RC07GF510J
R56	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R57	000153	RES	CARBON	15	K	5%	1/4 W	OHMITE	RC07GF153J
R58	000153	RES	CARBON	15	K	5%	1/4 W	OHMITE	RC07GF153J
R59	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R60	000151	RES	CARBON	150	OHM	5%	1/4 W	OHMITE	RC07GF151J
R61	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R62	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R63	000510	RES	CARBON	51	OHM	5%	1/4 W	OHMITE	RC07GF510J
R64	000510	RES	CARBON	51	OHM	5%	1/4 W	OHMITE	RC07GF510J
R65	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R66	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R67	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R68	000101	RES	CARBON	100	OHM	5%	1/4 W	OHMITE	RC07GF101J
R69	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
R70	040026	RES	VARI	20	K	10%	1 W	TECHNO	35
R71	020241	RES	WW	10	K	.05%	1/8 W	JORDAN	J-11
R72	000335	RES	CARBON	3.3	M	5%	1/4 W	OHMITE	RC07GF335J
R73	020554	RES	WW	1.1096	K	.05%		JORDAN	J11
R74	000911	RES	CARBON	910	OHM	5%	1/4 W	OHMITE	RC07GF911J
R75	020170	RES	WW	100.83	OHM	.05%	1/8 W	KELVIN	EP-20
R76	000305	RES	CARBON	3	M	5%	1/4 W	OHMITE	RC07GF305J
R77	040026	RES	VARI	20	K	10%	1 W	TECHNO	35
R81	000102	RES	CARBON	1	K	5%	1/4 W	OHMITE	RC07GF102J
S01	600590	SWITCH PUSHBUTTON						DANA	600590
S02	600590	SWITCH PUSHBUTTON						DANA	600590
S03	600590	SWITCH PUSHBUTTON						DANA	600590
S04	600590	SWITCH PUSHBUTTON						DANA	600590
S05	600590	SWITCH PUSHBUTTON						DANA	600590
S06	600590	SWITCH PUSHBUTTON						DANA	600590
S07	600590	SWITCH PUSHBUTTON						DANA	600590

PARTS LIST

ASSEMBLY 403449 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION		
S08	600590	SWITCH PUSHBUTTON	DANA	600590
S09	600590	SWITCH PUSHBUTTON	DANA	600590
S10	600590	SWITCH PUSHBUTTON	DANA	600590
W03	600245	JUMPER	GETTIG	L-2007-1
W04	600245	JUMPER	GETTIG	L-2007-1
W05	600245	JUMPER	GETTIG	L-2007-1
W06	600245	JUMPER	GETTIG	L-2007-1

PARTS LIST

ASSEMBLY 403214 - Model 600

A

REF. DESIG.	PART NO.	DESCRIPTION							
CR101	211236	DIODE	SILICO		007			DANA	211236
CR102	211236	DIODE	SILICO		007			DANA	211236
CR103	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR104	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR105	211083	DIODE	SILICO		018			DANA	211083
CR106	211083	DIODE	SILICO		018			DANA	211083
CR107	211083	DIODE	SILICO		018			DANA	211083
CR109	220015	DIODE	SILICO	ZENER	1N967B			MOTOROLA	1N967B
CR110	220015	DIODE	SILICO	ZENER	1N967B			MOTOROLA	1N967B
CR111	211083	DIODE	SILICO		018			DANA	211083
CR112	211083	DIODE	SILICO		018			DANA	211083
C101	120007	CAP	MYLAR	.22 MFD	600 V		20%	ELEC CUBE	210B1F224
C102	120197	CAP	POLYS	20 PFD	1000 V			DUCATI	20-1000
C103	130054	CAP	CERAM	1-5 PFD			10%	AMPREX	C010KA/5E
C104	120218	CAP	POLY	10 PF	630 V			MALLORY	SX410
C105	120161	CAP	POLYS	.047 MFD	63 V		2.5%	DIEL	N100
C106	120162	CAP	POLYS	.0044 MFD	63 V		2.5%	MIAL	611.2D
C107	120142	CAP	POLYS	FSV				DANA	120142
C108	130055	CAP	CERAM	5-60 PFD			10%	AMPREX	C010MA/60E
C109	120158	CAP	POLYS	390 PFD	63 V		5%	MIAL	611
C110	130055	CAP	CERAM	5-60 PFD			10%	AMPREX	C010MA/60E
C111	120034	CAP	POLYS	100 PFD	500 V		5%	CRL	CPR-100J
C112	130054	CAP	CERAM	1-5 PFD			10%	AMPREX	C010KA/5E
C113	120163	CAP	POLYS	15 PFD	63 V		5%	DIEL	N100
C114	120198	CAP	POLYS	12 PFD	500 V		20%	MALLORY	SX412
C115	110150	CAP	ELECT	200 MFD	10 V			AMPEREX	C426ARD200
C116	110047	CAP	ELECT	50 MFD	50 V		20%	DUCATI	50-50
C117	110047	CAP	ELECT	50 MFD	50 V		20%	DUCATI	50-50
C118	121393	CAP	MYLAR	.22 MFD	100 V		10%	CDE	WMF1P22
C119	101145	CAP	CERAM	100 PFD	500 V		10%	AEROVOX	SCD1X5F
C120	100008	CAP	CERAM	82 PFD	500 V		10%	AEROVOX	TCD-N750
C121	101145	CAP	CERAM	100 PFD	500 V		10%	AEROVOX	SCD1X5F
C122	110005	CAP	TANTA	10 MFD	50 V		10%	SEMCOR	TSW1K-50-1
C125	110022	CAP	TANTA	3.3 MFD	35 V		10%	KEMET	K33C35K
C126	110022	CAP	TANTA	3.3 MFD	35 V		10%	KEMET	K33C35K
J18	600326	CONN						WINCHESTER	JP3P-1S-AC

PARTS LIST

ASSEMBLY 403214 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION						
K101	310036	RELAY REED					ELEC-TROL	R2096-3
K102	310035	RELAY REED		SPST	24V		AZTEC	LIA24-S1
K103	310035	RELAY REED		SPST	24V		AZTEC	LIA24-S1
P17	600069	CONN 15 P					CINCH	2311512121
Q101	200085	TRANS		MPF103			MOTOROLA	MPF103
Q102	200022	TRANS SILICO PNP		012			DANA	200022
Q103	200052	TRANS SILICO PNP		009			DANA	200052
Q105	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q106	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q107	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q108	200136	TRANS					FAIRCHILD	SE4022
Q109	200136	TRANS					FAIRCHILD	SE4022
Q110	200022	TRANS SILICO PNP		012			DANA	200022
Q111	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q112	200068	TRANS		2N4250			FAIRCHILD	2N4250
Q113	200052	TRANS SILICO PNP		009			DANA	200052
Q114	200035	TRANS SILICO NPN		014			DANA	200035
R101	010356	RES METAL	MATCH SET				DANA	010356
R102	010356	RES METAL	MATCH SET				DANA	010356
R103	040104	RES VARI	50 K				BECKMAN	62P
R104	000243	RES CARBON	24 K		5%	1/4 W	OHMITE	RC07GF243J
R105	040114	RES VARI	50 K		10%		BECKMAN	62PR50
R106	010356	RES METAL	MATCH SET				DANA	010356
R107	040115	RES VARI	500 K		10%		BECKMAN	62PR500
R108	010356	RES METAL	MATCH SET				DANA	010356
R109	010356	RES METAL	MATCH SET				DANA	010356
R110	000201	RES CARBON	200 OHM		5%	1/4 W	OHMITE	RC07GF201J
R111	000104	RES CARBON	100 K		5%	1/4 W	OHMITE	RC07GF104J
R113	000332	RES CARBON	3.3 K		5%	1/4 W	OHMITE	RC07GF332J
R116	000202	RES CARBON	2 K		5%	1/4 W	OHMITE	RC07GF202J
R117	010321	RES METAL	10 OHM		1%		ELECTRA	RN60D10R0F
R118	040110	RES VARI	100 OHM				BBECKMAN	62PR100
R119	000102	RES CARBON	1 K		5%	1/4 W	OHMITE	RC07GF102J
R121	010356	RES METAL	MATCH SET				DANA	010356
R124	000202	RES CARBON	2 K		5%	1/4 W	OHMITE	RC07GF202J

PARTS LIST

ASSEMBLY 403214 - Model 600

A

REF. DESIG.	PART NO.	DESCRIPTION							
R125	000202	RES	CARBON	2 K	5%	1/4 W	OHMITE	RC07GF202J	
R126	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J	
R127	000752	RES	CARBON	7.5 K	5%	1/4 W	OHMITE	RC07GF752J	
R128	000105	RES	CARBON	1 M	5%	1/4 W	OHMITE	RC07GF105J	
R131	000106	RES	CARBON	10 M	5%	1/4 W	OHMITE	RC07GF106J	
R132	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J	
R133	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J	
R136	000203	RES	CARBON	20 K	5%	1/4 W	OHMITE	RC07GF203J	
R137	010356	RES	METAL	MATCH SET			DANA	010356	
R138	010356	RES	METAL	MATCH SET			DANA	010356	
R139	000106	RES	CARBON	10 M	5%	1/4 W	OHMITE	RC07GF106J	
R140	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J	
R141	000512	RES	CARBON	5.1 K	5%	1/4 W	OHMITE	RC07GF512J	
R142	000751	RES	CARBON	750 OHM	5%	1/4 W	OHMITE	RC07GF751J	
R143	000103	RES	CARBON	10 K	5%	1/4 W	OHMITE	RC07GF103J	
R144	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J	
R146	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J	
R147	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J	
R148	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J	
R149	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J	
R150	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J	
R151	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J	
R152	000331	RES	CARBON	330 OHM	5%	1/4 W	OHMITE	RC07GF331J	
R153	000331	RES	CARBON	330 OHM	5%	1/4 W	OHMITE	RC07GF331J	
R157	010356	RES	METAL	MATCH SET			DANA	010356	
R160	010060	RES	METAL	10 K	1%	1/4 W	ELECTRA	RN60D1002F	
R161	010356	RES	METAL	MATCH SET			DANA	010356	
R162	010060	RES	METAL	10 K	1%	1/4 W	ELECTRA	RN60D1002F	

PARTS LIST

ASSEMBLY 403109 - Model 600

A

REF. DESIG.	PART NO.	DESCRIPTION							
CR105	211083	DIODE	SILICO		018			DANA	211083
CR106	211083	DIODE	SILICO		018			DANA	211083
CR107	211083	DIODE	SILICO		018			DANA	211083
CR108	211083	DIODE	SILICO		018			DANA	211083
CR113	221177	DIODE	SILICO	ZENER			1/4 W	MOTOROLA	M.2.4A25
CR114	221177	DIODE	SILICO	ZENER			1/4 W	MOTOROLA	M.2.4A25
CR115	221177	DIODE	SILICO	ZENER			1/4 W	MOTOROLA	M.2.4A25
C123	121088	CAP	MYLAR	.01	MFD	100 V	10%	CDE	WMF1S1
C124	121146	CAP	MYLAR	.0047	MFD	100 V	10%	CDE	WMF1D47
C127	121146	CAP	MYLAR	.0047	MFD	100 V	10%	CDE	WMF1D47
K104	310036	RELAY	REED					ELEC-TROL	R2096-3
K105	310036	RELAY	REED					ELEC-TROL	R2096-3
K106	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
K107	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
M101	230026	INTEGRATED CIRCUIT		MC709C				MOTOROLA	MC709C
Q104	200043	TRANS	SILICO	NPN	2N3565			FAIRCHILD	2N3565
Q105	200043	TRANS	SILICO	NPN	2N3565			FAIRCHILD	2N3565
Q106	200043	TRANS	SILICO	NPN	2N3565			FAIRCHILD	2N3565
Q107	200043	TRANS	SILICO	NPN	2N3565			FAIRCHILD	2N3565
Q115	200043	TRANS	SILICO	NPN	2N3565			FAIRCHILD	2N3565
R112	000202	RES	CARBON	2	K	5%	1/4 W	OHMITE	RC07GF202J
R114	001737	RES	FSV			5%	1/4 W	DANA	001737
R115	040159	RES	VARI	500	K		1/2 W	BECKMAN	62PR500K
R116	000202	RES	CARBON	2	K	5%	1/4 W	OHMITE	RC07GF202J
R120	020494	RES	WW	8.19	K	.1%		JORDAN	J11
R122	020495	RES	WW	89.815	K	.1%		JORDAN	J11
R123	040115	RES	VARI	500	K	10%		BECKMAN	62PR500
R124	000202	RES	CARBON	2	K	5%	1/4 W	OHMITE	RC07GF202J
R125	000202	RES	CARBON	2	K	5%	1/4 W	OHMITE	RC07GF202J
R129	020496	RES	WW	996.15	K	.1%		JORDAN	J11
R130	040097	RES	VARI	5	K	10%		BECKMAN	62PR5K
R134	040104	RES	VARI	50	K			BECKMAN	62P
R135	010357	RES	METAL	8.981	MEG	.1%		PYROFILM	PME 70 T2
R145	000685	RES	CARBON	6.8	MEG	5%	1/4 W	OHMITE	RC07GF685J
R154	040088	RES	VARI	100	K	10%		BECKMAN	62PR100K
R155	001737	RES	FSV			5%	1/4 W	DANA	001737

PARTS LIST

ASSEMBLY 403169 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION							
R156	000152	RES	CARBON	1.5 K	5%	1/4 W		OHMITE	RC07GF152J
R158	000512	RES	CARBON	5.1 K	5%	1/4 W		OHMITE	RC07GF512J
R159	000821	RES	CARBON	820 OHM	5%	1/4 W		OHMITE	RC07GF821J
R163	000912	RES	CARBON	9.1 K	5%	1/4 W		OHMITE	RC07GF912J
R164	020050	RES	WW	9.0 K	.01%	1/4 W		KELVIN	EP-21
R165	021395	RES	WW	1 K	.01%	1/4 W		JORDAN	J-12

PARTS LIST

ASSEMBLY 402581 - Model 600

REF. DESIG.	PART NO.	DESCRIPTION							
CR101	211236	DIODE	SILICO		007			DANA	211236
CR102	211236	DIODE	SILICO		007			DANA	211236
CR103	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR104	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR105	211083	DIODE	SILICO		018			DANA	211083
CR106	211083	DIODE	SILICO		018			DANA	211083
CR107	211083	DIODE	SILICO		018			DANA	211083
CR108	211083	DIODE	SILICO		018			DANA	211083
CR109	220015	DIODE	SILICO	ZENER	1N967B			MOTOROLA	1N967B
CR110	220015	DIODE	SILICO	ZENER	1N967B			MOTOROLA	1N967B
CR111	211083	DIODE	SILICO		018			DANA	211083
CR112	211083	DIODE	SILICO		018			DANA	211083
CR113	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR114	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
CR115	221177	DIODE	SILICO	ZENER		1/4 W		MOTOROLA	M.2.4A25
C101	120007	CAP	MYLAR	.22	MFD	600 V	20%	ELEC CUBE	210B1F224
C102	120197	CAP	POLYS	20	PFD	1000 V		DUCATI	20-1000
C103	130054	CAP	CERAM	1-5	PFD		10%	AMPREX	C010KA/5E
C104	120218	CAP	POLY	10	PF	630 V		MALLORY	SX410
C105	120161	CAP	POLYS	.047	MFD	63 V	2.5%	DIEL	N100
C106	120162	CAP	POLYS	.0044	MFD	63 V	2.5%	MIAL	611.20
C107	120142	CAP	POLYS	FSV				DANA	120142
C108	130055	CAP	CERAM	5-60	PFD		10%	AMPREX	C010MA/60E
C109	120158	CAP	POLYS	390	PFD	63 V	5%	MIAL	611
C110	130055	CAP	CERAM	5-60	PFD		10%	AMPREX	C010MA/60E
C111	120034	CAP	POLYS	100	PFD	500 V	5%	CRL	CPR-100J
C112	130054	CAP	CERAM	1-5	PFD		10%	AMPREX	C010KA/5E
C113	120163	CAP	POLYS	15	PFD	63 V	5%	DIEL	N100
C114	120198	CAP	POLYS	12	PFD	500 V	20%	MALLORY	SX412
C115	110150								
C116	110047	CAP	ELECT	50	MFD	50 V	20%	DUCATI	50-50
C117	110047	CAP	ELECT	50	MFD	50 V	20%	DUCATI	50-50
C118	121393	CAP	MYLAR	.22	MFD	100 V	10%	CDE	WMF1P22
C119	101145	CAP	CERAM	100	PFD	500 V	10%	AEROVOX	SCD1X5F
C120	100008	CAP	CERAM	82	PFD	500 V	10%	AEROVOX	TCD-N750
C121	101145	CAP	CERAM	100	PFD	500 V	10%	AEROVOX	SCD1X5F

PARTS LIST

ASSEMBLY 402581 - Model 600 A

REF. DESIG.	PART NO.	DESCRIPTION							
C122	110005	CAP	TANTA	10	MFD	50 V	10%	SEMCOR	TSW1K-50-1
C123	121088	CAP	MYLAR	.01	MFD	100 V	10%	CDE	WMF1S1
C124	121146	CAP	MYLAR	.0047	MFD	100 V	10%	CDE	WMF1D47
C125	110022	CAP	TANTA	3.3	MFD	35 V	10%	KEMET	K33C35K
C126	110022	CAP	TANTA	3.3	MFD	35 V	10%	KEMET	K33C35K
C127	121146	CAP	MYLAR	.0047	MFD	100 V	10%	CDE	WMF1D47
J18	600326	CONN						WINCHESTER	JP3P-1S-AC
K101	310036	RELAY	REED					ELEC-TROL	R2096-3
K102	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
K103	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
K104	310036	RELAY	REED					ELEC-TROL	R2096-3
K105	310036	RELAY	REED					ELEC-TROL	R2096-3
K106	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
K107	310035	RELAY	REED		SPST	24V		AZTEC	LIA24-S1
M101	230026	INTEGRATED CIRCUIT		MC709C				MOTOROLA	MC709C
P17	600069	CONN	15 P					CINCH	2311512121
Q101	200085	TRANS			MPF103			MOTOROLA	MPF103
Q102	200022	TRANS	SILICO PNP		012			DANA	200022
Q103	200011	TRANS	SILICO PNP		009			DANA	200011
Q104	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
Q105	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
Q106	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
Q107	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
Q108	200136	TRANS						FAIRCHILD	SE4022
Q109	200136	TRANS						FAIRCHILD	SE4022
Q110	200022	TRANS	SILICO PNP		012			DANA	200022
Q111	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
Q112	200076	TRANS			2N4250			FAIRCHILD	2N4250
Q113	200011	TRANS	SILICO PNP		009			DANA	200011
Q114	200035	TRANS	SILICO NPN		014			DANA	200035
Q115	200043	TRANS	SILICO NPN		2N3565			FAIRCHILD	2N3565
R101	010356	RES	METAL	MATCH SET				DANA	010356
R102	010356	RES	METAL	MATCH SET				DANA	010356
R103	040104	RES	VARI	50 K				BECKMAN	62P
R104	000243	RES	CARBON	24 K		5%	1/4 W	OHMITE	RC07GF243J

PARTS LIST

ASSEMBLY 402581 - Model 600

A

REF. DESIG.	PART NO.	DESCRIPTION						
R105	040114	RES	VARI	50 K	10%		BECKMAN	62PR50
R106	010356	RES	METAL	MATCH SET			DANA	010356
R107	040115	RES	VARI	500 K	10%		BECKMAN	62PR500
R108	010356	RES	METAL	MATCH SET			DANA	010356
R109	010356	RES	METAL	MATCH SET			DANA	010356
R110	000201	RES	CARBON	200 OHM	5%	1/4 W	OHMITE	RC07GF201J
R111	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J
R112	000202	RES	CARBON	2 K	5%	1/4 W	OHMITE	RC07GF202J
R113	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J
R114	001737	RES	FSV		5%	1/4 W	DANA	001737
R115	040159	RES	VARI	500 K		1/2 W	BECKMAN	62PR500K
R116	000102	RES	CARBON	1 K	5%	1/4 W	OHMITE	RC07GF102J
R117	010321	RES	METAL	10 OHM	1%		ELECTRA	RN60D10R0F
R118	040110	RES	VARI	100 OHM			BBECKMAN	62PR100
R119	000102	RES	CARBON	1 K	5%	1/4 W	OHMITE	RC07GF102J
R120	020494	RES	WW	8.19 K	.1%		JORDAN	J11
R121	010356	RES	METAL	MATCH SET			DANA	010356
R122	020495	RES	WW	89.815 K	.1%		JORDAN	J11
R123	040115	RES	VARI	500 K	10%		BECKMAN	62PR500
R124	000102	RES	CARBON	1 K	5%	1/4 W	OHMITE	RC07GF102J
R125	000102	RES	CARBON	1 K	5%	1/4 W	OHMITE	RC07GF102J
R126	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J
R127	000752	RES	CARBON	7.5 K	5%	1/4 W	OHMITE	RC07GF752J
R128	000105	RES	CARBON	1 M	5%	1/4 W	OHMITE	RC07GF105J
R129	020496	RES	WW	996.15 K	.1%		JORDAN	J11
R130	040097	RES	VARI	5 K	10%		BECKMAN	62PR5K
R131	000106	RES	CARBON	10 M	5%	1/4 W	OHMITE	RC07GF106J
R132	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J
R133	000104	RES	CARBON	100 K	5%	1/4 W	OHMITE	RC07GF104J
R134	040104	RES	VARI	50 K			BECKMAN	62P
R135	010357	RES	METAL	8.981 MEG	.1%		PYROFILM	PME 70 T2
R136	000203	RES	CARBON	20 K	5%	1/4 W	OHMITE	RC07GF203J
R137	010356	RES	METAL	MATCH SET			DANA	010356
R138	010356	RES	METAL	MATCH SET			DANA	010356
R139	000106	RES	CARBON	10 M	5%	1/4 W	OHMITE	RC07GF106J

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REF. DESIG.	PART NO.	DESCRIPTION						
R140	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J
R141	000512	RES	CARBON	5.1 K	5%	1/4 W	OHMITE	RC07GF512J
R142	000751	RES	CARBON	750 OHM	5%	1/4 W	OHMITE	RC07GF751J
R143	000103	RES	CARBON	10 K	5%	1/4 W	OHMITE	RC07GF103J
R144	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J
R145	000685	RES	CARBON	6.8 MEG	5%	1/4 W	OHMITE	RC07GF685J
R146	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J
R147	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J
R148	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J
R149	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J
R150	000332	RES	CARBON	3.3 K	5%	1/4 W	OHMITE	RC07GF332J
R151	000101	RES	CARBON	100 OHM	5%	1/4 W	OHMITE	RC07GF101J
R152	000331	RES	CARBON	330 OHM	5%	1/4 W	OHMITE	RC07GF331J
R153	000331	RES	CARBON	330 OHM	5%	1/4 W	OHMITE	RC07GF331J
R154	040088	RES	VARI	100 K	10%		BECKMAN	62PR100K
R155	001737	RES	FSV		5%	1/4 W	DANA	001737
R156	000152	RES	CARBON	1.5 K	5%	1/4 W	OHMITE	RC07GF152J
R157	010356	RES	METAL	MATCH SET			DANA	010356
R158	000512	RES	CARBON	5.1 K	5%	1/4 W	OHMITE	RC07GF512J
R159	000821	RES	CARBON	820 OHM	5%	1/4 W	OHMITE	RC07GF821J
R160	010141	RES	METAL	10 K	.25%	1/4 W	PYROFILM	PME6010
R161	010356	RES	METAL	MATCH SET			DANA	010356
R162	010141	RES	METAL	10 K	.25%	1/4 W	PYROFILM	PME6010
R163	000912	RES	CARBON	9.1 K	5%	1/4 W	OHMITE	RC07GF912J
R164	020050	RES	WW	9.0 K	.01%	1/4 W	KELVIN	EP-21
R165	021395	RES	WW	1 K	.01%	1/4 W	JORDAN	J-12

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